AD-A101 313 ARMY ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND WS--ETC F/G 19/5
EXTENDING APPLICATION OF THE ARTILLERY COMPUTER METEOROLOGICAL --ETC(U)
MAY 81 A J BLANCO
UNCLASSIFIED ERADCOM-ASL-TR-0087 NL

1 OF 1
AD
A101313

END
DATE
FILMED
7-81
DTIC

LEVEL II (13)

AD

ASL-TR-0087

Reports Control Symbol
OSD-1366

AD A101313

EXTENDING APPLICATION OF THE ARTILLERY COMPUTER METEOROLOGICAL MESSAGE

MAY 1981

By

ABEL J. BLANCO

DTIC
ELECTE
JUL 1 4 1981
S D
H

Approved for public release; distribution unlimited

DTIC FILE COPY

US Army Electronics Research and Development Command
ATMOSPHERIC SCIENCES LABORATORY
White Sands Missile Range, NM 88002

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER -TR-0087	2. GOVT ACCESSION NO. AD-A101 313	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) EXTENDING APPLICATION OF THE ARTILLERY COMPUTER METEOROLOGICAL MESSAGE.		5. TYPE OF REPORT & PERIOD COVERED (9) Final Report.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Abel J./Blanco		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Atmospheric Sciences Laboratory White Sands Missile Range, NM 88002		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA Task (16) 1L162111AH71 (17) -F0
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Electronics Research and Development Command Adelphi, MD 20783 (11)		12. REPORT DATE May 1981
		13. NUMBER OF PAGES 34 (12) 44
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (14) ERADCOM-ASL-TR-0087		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Artillery meteorology
Meteorological error analysis
Extrapolating meteorological data
Extending Arty computer met message
High trajectory artillery
Ballistic meteorological displacement

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Preliminary results derived from a mathematical algorithm for calculating impact dispersion due to meteorological factors are presented. The report presents a comparison of three techniques for extending the maximum ordinate of the Artillery Computer Meteorological Message from 20 to 23 km, for application to projectiles traversing higher altitudes. The three techniques, called the default, the extrapolation, and the modified extrapolation (or climatological), are analyzed against data from 69 rocketsonde flights that

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

410

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (cont)

were conducted over White Sands Missile Range, New Mexico, during 1979. The measured and estimated data are used to ballistically simulate 552 impact displacements for a trajectory of a proposed rocket system. The findings show that the extrapolated meteorological correction yields a significant improvement over the current default method of using a standard meteorological message. Impact dispersion error analyses illustrate that a software addition to the current meteorological message procedure predicts all impacts within the current one probable error when the meteorological message is extended 3 km in altitude.

SUMMARY

The United States Army Field Artillery School needs to know the expected meteorological impact displacement for new weapons traversing the atmosphere to altitudes where measurements are not available from the meteorological field units. The preliminary status is that simple persistence for extrapolating the wind, extending temperature by adding the standard gradient to the last known temperature value, and using the hydrostatic extrapolation of density and pressure significantly reduces the meteorological impact error. The improvement is summarized as allowing all impacts to locate within the current one probable error dispersion. A software addition to the current meteorological message procedure reduces the error when the message is extended 3 km in altitude.

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A

CONTENTS

PRECEDING PAGE BLANK-NOT FILMED

INTRODUCTION

With advanced technology in artillery ballistics, projectile delivery at ranges greater than 50 km can be expected. Under certain conditions these projectiles will traverse altitudes higher than 20 km above ground level (AGL). The expected meteorological effects on the target displacement error need to be investigated for projectile traversals beyond 20 km AGL because the current computer meteorological message reports information only to 20 km AGL. This report presents preliminary results from a comparison of three techniques that extend the maximum ordinate of the artillery meteorological message for application to projectiles traversing higher than the 20 km meteorological message limit. The comparison really reduces to the question of how well the actual meteorological profile can be estimated from available information at the lower altitudes.

The techniques investigated include the current default method of using a standard meteorological message, the method of extrapolating available data from lower levels, and the method of using climatological values. The report illustrates the effect of the default method in assuming zero wind and using temperature and density and pressure profiles representative for global applications. The method of extrapolating wind, temperature, and density and pressure provided the smallest expected (meteorological) impact displacement for the sample considered. For extrapolations extended up to 3 km beyond the 20 km current maximum altitude, the extrapolated values proved to be good estimates of the actual ballistic parameter values effecting the projectile impact. The climatological method which required adjusted corrections from available information at the lower altitudes also showed a significant improvement over the default method. The meteorological impact errors are smaller than those allowed from the default method but larger than those allowed from the extrapolated method. Climatological input is also required. The method is included in this study because it may prove advantageous when extrapolated values are needed at ranges which cause the ballistic trajectory to exceed the extended 3 km height.

The development of the extended meteorological message techniques and ballistic simulation programs was tested by using a single rocket configuration. The selected trajectory reaches 65 km range and traverses 23 km AGL in altitude. Data needed to describe this trajectory (for example, ballistic wind and temperature and density coefficients including weighting factors and unit effects) were obtained from the Project Manager of the Multiple Launched Rocket Systems (MLRS).* To attain this altitude, the projectile had to be launched at 3048 m above sea level; consequently, the meteorological extending techniques could be evaluated at the 23 to 26 km level of the lower stratosphere. As is the case for the artillery techniques for aiming a gun[1] on a target, this report uses the launcher surface as the zero level.

---

*Personal communication between Mr. Henry Oldham, Missile Command, and Dr. Donald M. Swingle, Atmospheric Sciences Laboratory, January-February 1980

[1]Field Manual 6-40, June 1974, <u>Field Artillery Cannon Gunnery</u>, Department of the Army Field Manual, Headquarters, Department of the Army, Washington DC

PRECEDING PAGE BLANK-NOT FILMED

EXTENDING METEOROLOGICAL APPLICATION

Available techniques for extending the meteorological data for projectiles reaching higher than 20 km AGL vary from hardware and software or a combination of these. In this report only software techniques will be discussed. The rocketsonde data are assumed to represent the actual atmospheric parameters; then the extending technique comparison reduces to how well the actual meteorological profile can be estimated from available information below the 20 km AGL limit. Also, the implication is that if these measured meteorological data are used for aiming an artillery piece, then the displacement due to meteorology on the target is zero. When the true meteorological data are known, the simulated fire provides a hit every time.

The first technique examined--one which the Artillery currently uses--will be called the default method. Whenever a meteorological message or climatological tables are unavailable, the artillery pieces are aimed by using a meteorological message which contains standard temperature and pressure and density data. The standard wind is a constant zero speed for all (line numbers) layers. In cases where the meteorological messages are unavailable or are not complete to the 20 km AGL limit, the current procedure defaults to the standard meteorological conditions for the missing data.

The second technique is extrapolation. The missing data are defined from the last available layer and are used to estimate the remainder of the meteorological message for application up to the maximum ordinate of the artillery projectiles. A persistent wind is used which is the wind direction and windspeed at the 20 km layer held constant up to the apogee of the trajectory. The extended values for temperature are computed by adding the standard gradient of the temperature default method to the last known temperature value. Finally, for the last parameters, the hydrostatic extrapolation of the density and pressure is computed by using the extrapolated temperature values and available density and pressure value. The detailed extrapolation, assuming the hydrostatic equation and the perfect gas law, yields the following expressions:

Gravity $g_0 = 9.80665 \text{ m s}^{-2}$

Air molecular weight $M = 28.966 \text{ g mol}^{-1}$

Gas constant $R = 8314.32 \text{ J } (°K)^{-1} \text{ mol}^{-1}$

Geopotential layer $$\Delta H(I) = \left(\frac{9.7376}{g_0}\right)(I)(1000)\text{m}$$

where I = 1, 2, 3

Extended temperature $$T(I) = T_0 + T_S(I) - T_{S_0}$$

where T_0 = 20 km value

T_S = standard temperature

T_{S_0} = standard temperature at 20 km

$T \rightarrow °C$

Lapse rate $L(I) = [T(I) - T_0]/\Delta H(I)$

$$L \rightarrow (°K)\ km^{-1}$$

Extended density

$$\rho(I) = \rho_0 \left[\frac{T_0 + 273.16}{T(I) + 273.16}\right]^{(1 + \frac{gM}{RL})}$$

where ρ_0 = 20 km value

$$\rho \rightarrow g/m^3$$

The extrapolated values for the layers of 1 km thickness are extended by iterating the above relationships with respect to I until the maximum altitude desired is reached.

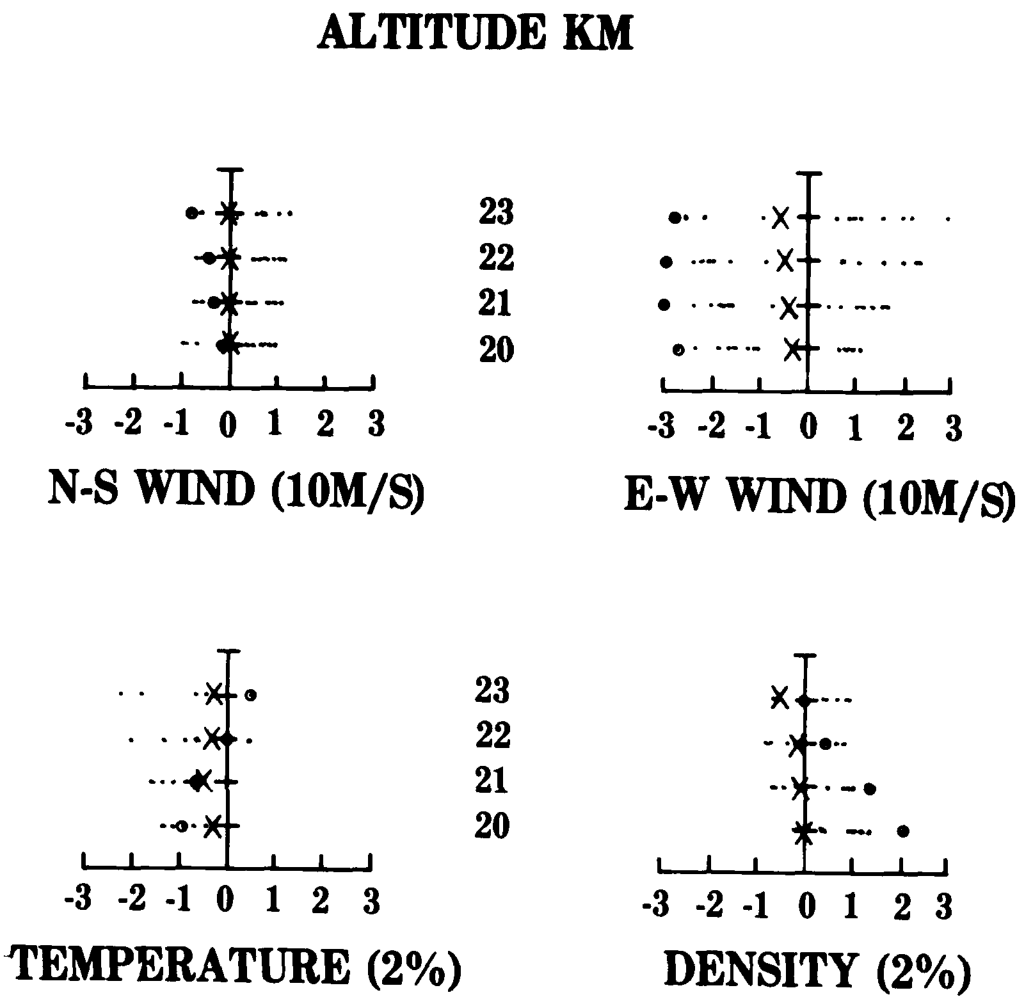
The third technique is defined by a modification to the extrapolated technique. This method uses climatological data to estimate values of the unavailable data. The difference between the data at the 20 km AGL layer and the data of the climatological values for the time of year and location of actual meteorological application is used to adjust the climatological estimate. Even though the Field Artillery does not have climatological tables available for these extended heights, this technique was included to develop the concept of translating the meteorological trend from climatological or fallout meteorological messages to continue the extended meteorological message from the 20 km AGL values.

The US Army Field Artillery needs an estimate of the meteorological impact displacement for proposed high trajectory weapons. Therefore, the emphasis of this report is to estimate the ballistic meteorological effects and not the actual value of the missing meteorological data at the extended altitudes. The three methods for extending meteorological data above the altitude actually measured are then transformed into a departure from a selected meteorological standard, and the error in failing to estimate the ballistic atmospheric effect will be illustrated by a displacement about the target. In summary, figure 1 illustrates the percent departures, plotted as (.), from the United States Standard Atmosphere (USSA) 1962[2] for 16 rocketsonde data flights collected during January 1979. This is the standard atmosphere the Ballistic Research Laboratory uses for trajectory computations.[3] The departures for the

---

[2] US Standard Atmosphere, 1962, December 1961, National Aeronautics and Space Administration, United States Air Force, United States Weather Bureau

[3] William Barnhart, 1966, "The Standard Atmosphere Used by BRL for Trajectory Computations," BRL MR 1766, US Army Materiel Command, Ballistic Research Laboratory, Aberdeen Proving Ground, MD



(.) January rocketsonde data

(X) January climatological data

(O) January 4, 1979, 1900 hours, data

Figure 1. Percent departures from the 1962 United States Standard Atmosphere 16 rocketsonde data flights.

month's climatological data are also plotted (x). Extending technique 1 uses the default value of the USSA (no departure). Technique 2 uses the wind components measured at the 20 km layer and also uses this value at the 21, 22, and 23 km layers. The extended values for the departure temperatures and density and pressure values are the normalized deviations between the extended values and corresponding values of the USSA. Technique 3 adds the climatological data with respect to the corresponding heights and the difference between the last available data and the climatology at 20 km to compute the data at the missing layers. By superimposing the climatological departure value (x) on a particular value of the 20 km level, one computes the difference that will be arithmetically added to the remaining climatological profile levels.

BALLISTIC SIMULATION

A comparison of the impact dispersions (realized by three techniques) was reviewed to evaluate the extending techniques and to gain some insight on the effect of the extended meteorological message. This report assumes that the actual meteorology is defined as the measured parameters deduced from the rocketsonde data.[4] These data were then represented in the Artillery computer meteorological message format[5] with new layers of 1 km thickness added to complete an extended message to 23 km AGL. The investigated techniques used measured data below 20 km AGL and extrapolated or climatological data for each layer up to the maximum ordinate of 23 km AGL. Using the same data, each extending method yields a dispersion about an assumed target. The meteorological technique that yields the smallest dispersion about the simulated target is selected as the best of those tested.

The corresponding dispersions are defined as the group of displacements calculated by the ballistic weighting technique. Here an algorithm is introduced that utilizes the extended messages and ballistically computes a displacement about a fixed target. This algorithm can be used to compute the deviation between the extended and a standard (USSA) method. This deviation is then normalized with respect to the standard (USSA) condition. The deviation is calculated for the averaged parameter (wind, temperature, density and pressure) $\overline{P}(Z)$ at each layer through 23 km. Finally, in the ballistic technique, the normalized parameter is multiplied by the weighted response function $[\delta w'(Z)]$. This function contains the ballistic characteristics of the high trajectory weapon system. The required information is the weighting factors and the unit effect for each of the meteorological parameters at the identical layer structure of the extended messages under evaluation. The sum of these products through the maximum altitude of the proposed trajectory yields the effective displacement (D) from the standard conditions. In reality, by knowing this displacement, an artilleryman can compensate for the meteorological deviations from the standard by appropriately adjusting his weapon aim and firing for effect. This displacement is formulated as follows:

---

[4]Federal Meteorological Handbook No. 10, July 1975, Meteorological Rocket Observations, National Aeronautics and Space Administration, US Department of Commerce, US Department of Defense

[5]Field Manual 6-15, August 1978, Artillery Meteorology, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC

$$D = \int_{Z_0}^{Z} \delta\omega'(Z)\left[\frac{\overline{P}(Z) - \overline{P}_s(Z)}{\overline{P}_s(Z)}\right] dZ , \quad (1)$$

where δ = unit effect; $\omega'(Z)$ = ballistic weighting; dZ is the increment of height; and the parameter $\overline{P}(Z)$ is temperature, density, or wind. In the case of wind there is no standard, and the $\overline{P}(Z)$ is not normalized.

A sample of rocketsonde flights containing different atmospheric conditions yields a set of impact displacements describing the dispersion of the analyzed weapon system. This dispersion is mathematically represented with a bias and a variance for each component (cross and range) about the target. The conventional artillery practice is to describe the dispersion of a weapon in terms of a circular error probable (CEP).[1] This criterion is defined as the circular radius of the smallest circle about the target that contains one-half of the total impact displacements. This procedure is used even though the actual dispersion of a gun is elliptical. In demonstrating the differences between the evaluated extending techniques, this report uses elliptical probable error rather than the CEP. There are cases when a small dispersion is biased too far from the target, thereby yielding artillery fire ineffective. One is cautioned that when converting to CEP about the target the comparison of results will produce a different interpretation of the evaluated meteorological messages. The bias due to meteorological parameters is a major contributor to the impact displacement. In practice, through observed fire the Fire Direction Center would correct for this bias which is caused from the unavailability of a meteorological message update or lack of a procedure to obtain data above 20 km AGL.

The results show that the dispersion is a function of the atmospheric condition. Wind, temperature, and density and pressure effect the range impact displacement, while only wind effects the cross component.[5] Since the azimuth of fire determines the wind bias, calculation of a mathematical composite of eight single azimuth (θ_i) dispersions was considered to be more appropriate. The weapon system was therefore launched at targets on a circle of radius of 65 km at increments of 45 degrees. Figure 2 illustrates the one-probable-error dispersions produced from 16 rocketsonde flights collected during the same month and at the same location. All impacts were computed without an extended meteorological correction between 20 to 23 km AGL. The effectiveness of fire is different for the particular target. This report groups the 128 impact displacements and defines the composite dispersion plotted in the center of figure 2. Notice that the range and cross bias due to the wind are cancelled in the composite dispersion. This cancellation would also be true for a single azimuth target if the sample rocketsonde data included winds from all directions. The temperature and density and pressure

---

[1]Field Manual 6-40, June 1974, Field Artillery Cannon Gunnery, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC

[5]Field Manual 6-15, August 1978, Artillery Meteorology, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC

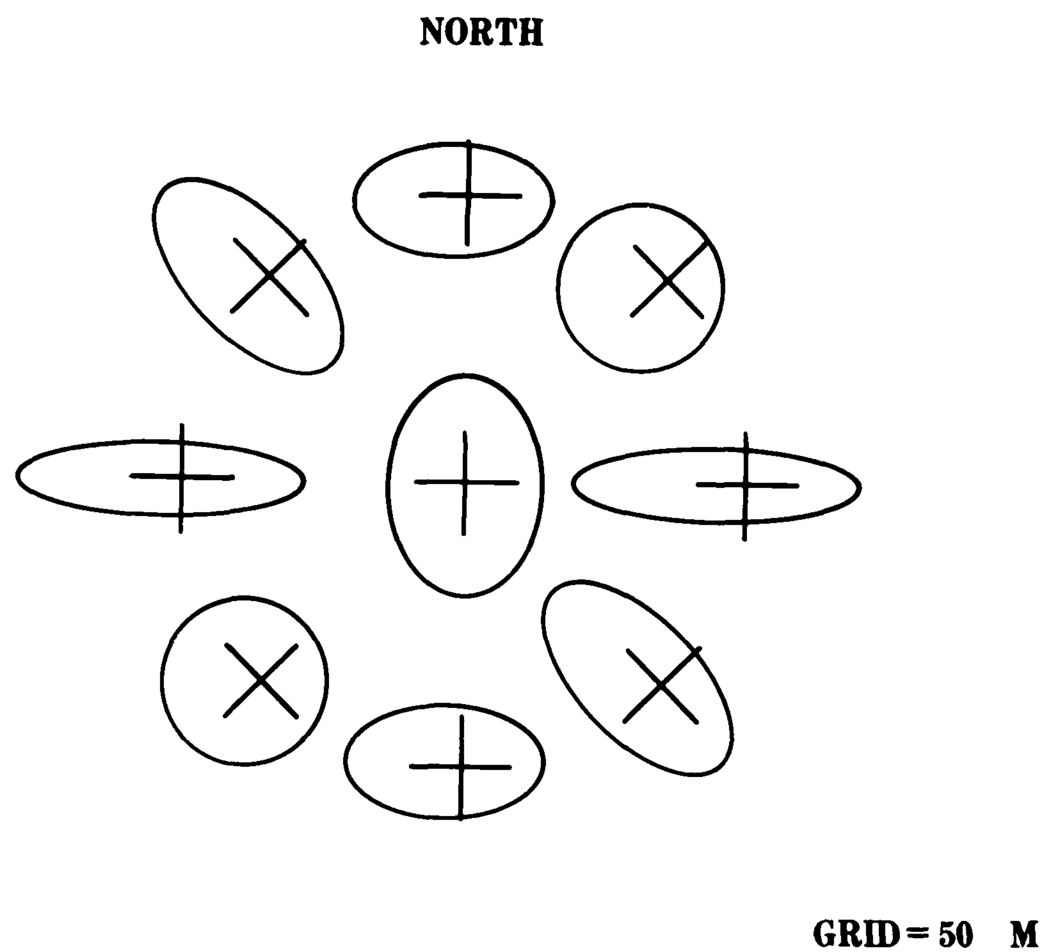


Figure 2. One probable error elliptical dispersions from 16 impact displacements computed without extended meteorological correction between 24 and 26 km above mean sea level. The weapon system is fired at targets on a circle of radius 65 km at 45-degree increments. The center dispersion is the mathematical composite of the 128 displacements.

bias are not cancelled because of the nature of the ballistic computation. If the sample contained data with the temperature and density and pressure above and below the standard, then the bias would be effected in the composite. The next section will present results for the rocketsonde data collected during different months illustrating the variation of temperature and density and pressure effects. The composite results can be interpreted as results of a large sample containing 128 rocketsonde flights collected on the same month. With the inclusion of several months of data collected at one location and following the outlined procedure, the final results can be interpreted for general application.

For each rocketsonde flight, equation (1) is applied to the cross (D_C) and range (D_R) components as follows:

$$D_{C_i}(\theta_j, Z) = \delta_C \sum_{Z_0}^{Z} \omega_C'(Z)\overline{W}_{C_i}(\theta_j, Z) \; ; \qquad (2)$$

$$D_{R_i}(\theta_j, Z) = \delta_R \sum_{Z_0}^{Z} \omega_R'(Z)\overline{W}_{R_i}(\theta_j, Z) + \delta_T \sum_{Z_0}^{Z} \omega_T'(Z)\frac{\Delta T_i}{T_S} + \delta_\rho \sum_{Z_0}^{Z} \omega_\rho'(Z)\frac{\Delta\rho_i}{\rho_S}. \qquad (3)$$

The cross component does not contain the temperature (T) and density (ρ) effects as illustrated in equation (3). The displacement statistics for the error due to the unextended meteorological message are computed as follows:

$$\text{Bias} = \sum_{i}^{n} \sum_{j}^{8} D_i(\theta_j, Z)/8n \; ; \qquad (4)$$

$$\text{Variance} = \frac{8n \sum_{i}^{n} \sum_{j}^{8} D_i(\theta_j, Z)^2 - \left[\sum_{i}^{n} \sum_{j}^{8} D_i(\theta_j, Z)\right]^2}{8n(8n - 1)} . \qquad (5)$$

Generalizing the results, consider that for each (i) rocketsonde flight there are (j = 8) azimuths providing a total of 8n impact displacements for each month.

TECHNIQUE COMPARISON

Measurements from 69 rocketsonde data flights collected at White Sands Missile Range (WSMR), New Mexico, during January through June 1979 were used to compute the meteorological displacement for the high trajectory projectile at the simulated 65 km range target. Since the evaluation of the three proposed extending techniques is based on the comparison of the dispersion from the

simulated displacements, the formula in equation (1) is computed for heights of 20 through 23 km AGL. These computations represent the meteorological effects which are not compensated for when the selected projectile is fired. However, use of extending meteorological data techniques will provide meteorological compensation for the missing data and should improve the accuracy.

The meteorological effect from surface through 20 km AGL is not computed in this report since the first 20 km of data are the same for each of the three extended meteorological messages. The extended meteorological message that best estimates the rocketsonde data will yield the smallest dispersion about the target at 65 km range. Only the displacement due to meteorology above 20 km is analyzed and illustrated in table A-1 in appendix A. In table A-1, J = 0 indicates the expected miss distance when using the current method which defaults to using standard meteorology when no other meteorological data are available. The largest displacement is 164 m and the smallest is 19 m. Note that this study assumes that there is no time and space difference between the point of measurement and application. For an actual firing, these errors are further increased by a factor determined from the time and space variability.

Table A-1 indicates that the presently used default values for the meteorological message above 20 km AGL yield large displacement variations that the Field Artillery should be correcting.

For J = 1 this table contains a list of the miss distance computed when an extrapolation defined from the last available layer is used to estimate the missing three meteorological data layers. Values in this table for J = 2 represent the displacements expected when persistent meteorology is modified by climatological gradients. The following interpretation can be made from table A-1: If the high trajectory projectile were fired on a cross-road target located 65 km in range on 4 January 1979, 1900 hours, using the current artillery default method, it would miss the target by 164 m. The smallest miss for the month is 50 m (17 January) and this assumes that there are no other time and space associated meteorological contributions. This unacceptable error can be improved significantly by any of the proposed extending techniques. By the simple extrapolated technique, the 164-m miss is reduced to 37 m and the 50-m miss to 17 m. A statistical extrapolation technique may provide further improvement. This improvement is expected from the better estimate of the wind and density effect. The temperature related errors are small because the variations at 23 to 26 km (above mean sea level) were small; and when normalized with the standard (in degrees Kelvin), the ballistic effect is a minimum as shown in table A-1.

Appendix B contains a flowchart illustrating the procedure automated to compute the expected meteorological errors associated with the high trajectory profile. The algorithm compares the statistics from the evaluated techniques. In summary, the no-correction or the default displacement is computed first by setting J = 0. This error is the total effect of the extended layers as computed from the actual rocketsonde data. For each flight, this displacement is saved for comparison with the other evaluated techniques. The difference and square of difference are saved to compute statistics leading to description of the one probable error, elliptical dispersion. In detail the miss distance is defined, using no-correction or default standard, as J0 (C0, R0). E(C1, R1) is the miss distance computed by

using the extrapolated correction. The miss distance provided from the climatology method is labeled as E(C2, R2). The differences J1 and J2, where

$$J1 = E(C1, R1) - J0(C0, R0),$$
$$J2 = E(C2, R2) - J0(C0, R0), \qquad (6)$$

provide the comparative values for the evaluated methods. A difference equal to zero indicates that the extended method has fully compensated for the actual extended values. The value of the difference is the error that remains uncompensated. By grouping the corresponding displacements, one can then compare the evaluated technique dispersions.

Table 1 presents statistics based on data from table A-1. The statistics are partitioned into the January, February, March, April, May, and June subsets of 16, 13, 12, 12, 8, and 8 rocketsonde data flights. An analysis of the total sample shows that there is a 64 percent improvement afforded by the extrapolated method over the current default method. Figure 3 presents a graphic demonstration of improved accuracy.

To assure the reader that this sample provides representative results, a test of significance was performed. The chi square distribution test involves the comparison of the computed displacements versus the expected displacements. A desired risk is selected, and a test statistic is compared with the chi square table value.[6] This test statistic is defined as follows:

$$\chi^2 = \sum_{i}^{n} \frac{(O_i - E_i)^2}{E_i}, \qquad (7)$$

where O_i is the observed frequency of occurrence of the computed displacements, E_i is the expected frequency of displacement for the different technique, and χ^2 is the computed chi square value.

For ease in organizing the results, a contingency table is arranged in table 2. The expected number of less than 30 m displacement is computed as follows: If there were no difference in the effect of the three techniques, the fraction of displacement with better than 30 m would be expected to be the same ratio as the totals in the last column of table 2. The number of the sample displacements is multiplied by this ratio to define the expected results. The computed value of χ^2 is greater than 34. Since the calculated value exceeds the table value (10), the conclusion is that the data indicate a difference from the expected value with a risk less than 0.005.

---

[6]Albert D. Rickmers and Hollis N. Todd, 1967, Statistics An Introduction, McGraw-Hill Book Company, New York

TABLE 1. COMPARISON OF RMS MISS FOR THREE EXTRAPOLATED MET MESSAGES USED AS INPUT FOR SIMULATED TRAJECTORY

$$\left(\overline{M}^2 + \sigma_{\overline{M}}^2\right)^{1/2} \text{ in meters}$$

	Jan	Feb	Mar	Apr	May	Jun	Total
Sample size	16	13	12	12	8	8	69
Rocketsonde	———Actual impact———						
Techniques (20-23 km)							
Default standard	106	55	58	64	74	89	78
Extrapolated	36	25	30	27	12	20	28
Climatology	43	39	46	27	18	27	37

TABLE 2. CONTINGENCY TABLE BASED ON RESULTS OF TEST OF THREE EXTENDING METEOROLOGICAL TECHNIQUES

Technique J =	0	1	2	Total
Total displacement	69	69	69	207
$\leq$ 30 m criteria	5	50	37	92
Expected improvement	30.7	30.7	30.7	

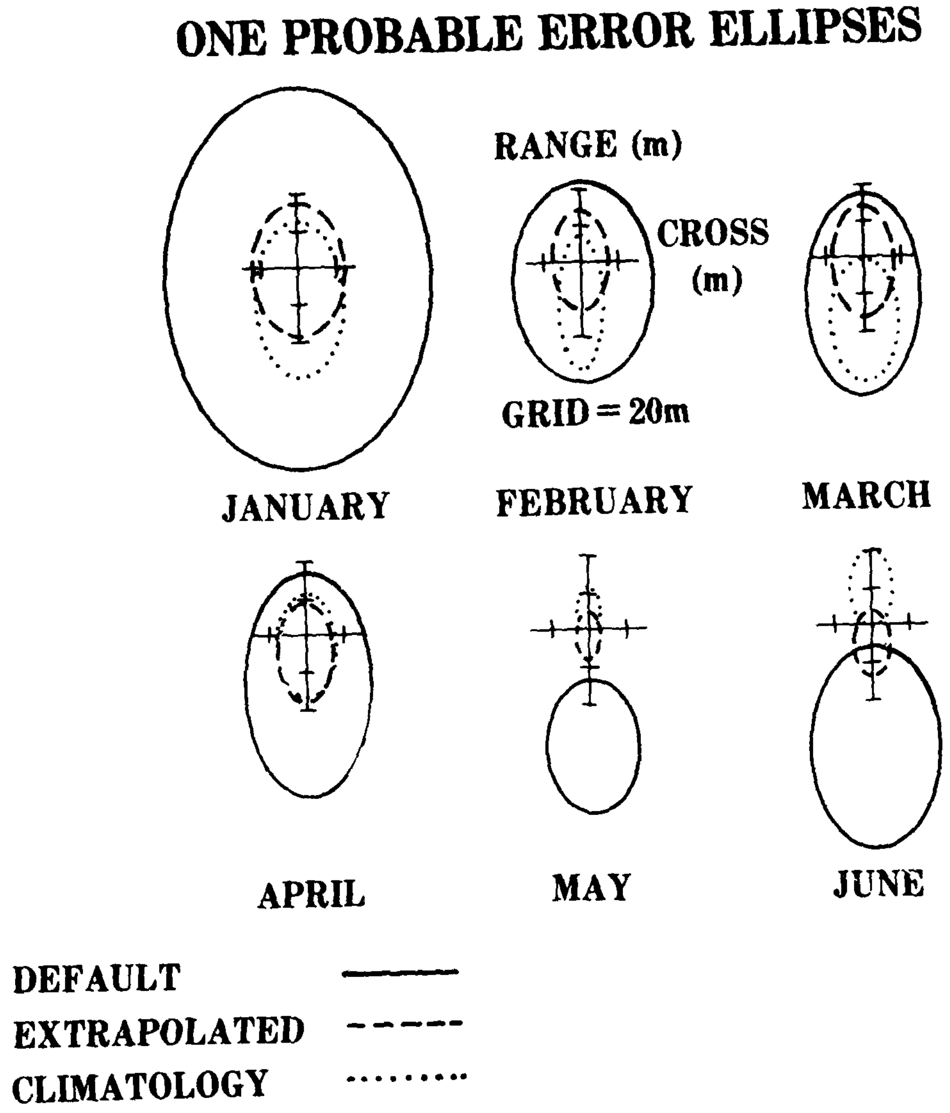


Figure 3. Graphic display of improved one probable error afforded by the extrapolated and climatological messages.

CONCLUSIONS

There is a large variation in the displacement effect due to the measured rocketsonde data collected at 23 through 26 km above mean sea level. For this theoretical study, the largest meteorological displacement in the sample size of 69 is 164 m and the smallest is 19 m. Note that for an actual firing these errors are further increased by a factor determined from the time and space differences between the point of measurement and application of the meteorological data. Under the assumption of no time and space variability, extrapolated meteorological data above 20 km AGL yielded a significant improvement over the current default method of using a standard meteorological message. The total rms 78-m displacement error was reduced to 28 m. The comparison reduces to how well the actual meteorological profile can be estimated from available information. If the estimate is poor, then actual measurements become important. Preliminary results for the high trajectory projectile considered indicate that a software addition to the current message procedure may be sufficient. This indication appears to be true when the meteorological message is extended 3 km in altitude for compensating meteorological effects on a 65 km range trajectory.

The next report to the United States Field Artillery School will present the status on the accuracy and dispersion effects on target impact displacement provided by using statistical extrapolation techniques. The improvement expected originates from bounded physical estimates of density and temperature effects and modified persistent winds with expected wind gradient effects. Instead of climatology, the last available fallout message can be used to provide the trend of the missing data. A more representative case of a high trajectory traversing to the middle stratosphere will be investigated. Under this condition, the default method of using the standard meteorological message is expected to yield increasingly larger errors.

REFERENCES

1. Field Manual 6-40, June 1974, Field Artillery Cannon Gunnery, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC.

2. "US Standard Atmosphere, 1962," December 1962, National Aeronautics and Space Administration, United States Air Force, United States Weather Bureau.

3. Barnhart, William, June 1966, "The Standard Atmosphere Used by BRL for Trajectory Computations," BRL MR 1766, US Army Materiel Command, Ballistic Research Laboratories, Aberdeen Proving Ground, MD.

4. Federal Meteorological Handbook No. 10, July 1975, Meteorological Rocket Observations, National Aeronautics and Space Administration, US Department of Commerce, US Department of Defense.

5. Field Manual 6-15, August 1978, Artillery Meteorology, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC.

6. Rickmers, Albert D., and Hollis N. Todd, 1967, Statistics An Introduction, McGraw-Hill Book Company, New York.

APPENDIX A

METEOROLOGICAL ERRORS AND ROCKETSONDE DATA

All information catalogued in table A-1 is expressed in meters and is the expected meteorological errors caused by the unavailable information at the extended heights (20 to 23 km) of the artillery computer meteorological message. For general interpretation of results, the statistics for each rocketsonde flight were computed from ballistic simulated firings at targets 65 km range and 45-degree azimuth intervals. The standard deviation and bias are listed, and the total statistics are summarized at the bottom of each month's results. Remember that for an actual application these errors are increased by a factor determined from the time and space difference between the points of measurement and application of meteorological corrections.

The information catalogued in table A-2 presents the rocketsonde data at the extended heights. The height is multiplied by ten to get the distance from mean sea level. In comparison to table A-1, these three 1-km layered data correspond to the 21, 22, and 23 km extension of the artillery meteorological message which is referenced to the launcher level. At the bottom of each month's data the climatology, standard atmosphere, and statistics for each layer are presented. Statistics are expressed in indicated units, the azimuth in degrees and the speed in meters per second, the temperature in degrees centigrade, and the density grams per cubic meter.

TABLE A-1. METEOROLOGICAL ERRORS

Iflight= 16 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	1	4	1900	89.33	137.35	163.84	0	-.00	-29.54	.74	-28.80
79	1	4	1900	14.88	33.49	36.65	1	00	-31.60	6.83	-24.77
79	1	4	1900	9.59	66.43	67.12	2	0.00	-72.30	7.47	-64.83
79	1	5	1900	76.27	115.55	138.45	0	-.00	-15.97	3.82	-12.15
79	1	5	1900	16.94	25.75	30.83	1	-.00	-2.69	1.82	-.87
79	1	5	1900	10.87	27.36	29.44	2	-.00	-24.25	2.48	-21.76
79	1	8	2030	68.98	104.17	124.94	0	.00	-7.44	5.00	-2.44
79	1	8	2030	18.28	28.51	33.87	1	-.00	-8.38	2.57	-5.81
79	1	8	2030	17.85	40.19	43.98	2	-.00	-32.77	3.21	-29.57
79	1	11	1945	62.20	94.60	113.22	0	-.00	-18.27	7.27	-11.00
79	1	11	1945	23.11	35.20	42.11	1	0.00	-3.55	2.23	-1.32
79	1	11	1945	23.75	47.71	53.30	2	0.00	-33.99	2.84	-31.15
79	1	12	1900	73.05	110.25	132.25	0	.00	-3.24	2.10	-1.14
79	1	12	1900	19.78	31.85	37.49	1	-.00	-16.09	5.47	-10.62
79	1	12	1900	17.06	44.10	47.28	2	-.00	-41.75	6.11	-35.64
79	1	15	2230	58.57	89.34	106.83	0	.00	-14.24	1.73	-12.51
79	1	15	2230	4.50	11.29	12.16	1	0.00	12.59	-3.81	8.77
79	1	15	2230	7.28	14.31	16.06	2	0.00	12.00	-3.05	8.95
79	1	16	2145	65.79	99.32	119.13	0	-.00	1.37	4.82	6.19
79	1	16	2145	14.87	24.81	28.92	1	0.00	11.71	-1.11	10.60
79	1	16	2145	19.38	29.63	35.40	2	0.00	5.26	-.42	4.84
79	1	17	2010	26.82	41.63	49.52	0	0.00	-13.34	3.36	-9.98
79	1	17	2010	6.53	15.11	16.46	1	-.00	15.07	-3.52	11.56
79	1	17	2010	7.62	14.66	16 52	2	-.00	12.02	-2.78	9.24
79	1	18	1720	25.73	45.65	52.40	0	.00	-23.92	.01	-23.91
79	1	18	1720	15.53	25.20	29.60	1	-.00	-10.74	1.77	-8.97
79	1	18	1720	16.28	37.25	40.66	2	-.00	-30.39	2.48	-27.91
79	1	19	1930	47.27	71.62	85.82	0	.00	-3.77	-1.54	-5.31
79	1	19	1930	25.24	38.34	45.90	1	0.00	-3.24	1.38	-1.85
79	1	19	1930	26.50	40.85	48.69	2	0.00	-9.38	2.12	-7.26
79	1	23	1835	36.94	55.68	66.82	0	-.00	-7.40	3.45	-3.95
79	1	23	1835	6.22	11.86	13.39	1	-.00	10.82	-3.60	7.22
79	1	23	1835	8.77	14.38	16.85	2	-.00	8.35	-2.86	5.49
79	1	24	1915	52.27	81.11	96.49	0	0.00	17.05	2.73	19.78
79	1	24	1915	12.96	19.48	23.40	1	0.00	1.01	-.95	.06
79	1	24	1915	15.78	23.73	28.50	2	0.00	.04	-.24	-.19
79	1	25	1800	45.00	71.45	84.44	0	- 00	-34.87	11.98	-22.89
79	1	25	1800	11.93	19.80	23.12	1	0.00	8.94	-.55	8.39
79	1	25	1800	12.15	32.51	34.70	2	.00	-26.94	.04	-26.90
79	1	26	1800	34.36	52.89	63.08	0	.00	-27.69	16.24	-11.45
79	1	26	1800	8.68	19.89	21.70	1	0.00	21.73	-6.74	14.39
79	1	26	1800	7.58	14.57	16.42	2	-.00	-2.97	-6.13	-9.10
79	1	29	1700	67.03	101.72	121.82	0	-.00	5.39	3.46	8.84
79	1	29	1700	41.13	63.11	75.73	1	0.00	-13.68	4.11	-9.57
79	1	29	1700	42.14	70.87	82.45	2	0.00	-35.36	4.75	-30.61
79	1	30	1900	57.92	91.08	107.94	0	-.00	29.33	-3.44	25.89
79	1	30	1900	27.85	43.21	51.41	1	0.00	-14.97	5.22	-9.74
79	1	30	1900	28.24	44.16	52.42	2	0.00	-17.24	5.93	-11.31

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
-.00	58.48	68.85	-5.30	89.35	105.20	0	106.5
-.00	19.15	22.55	-.75	30.82	36.28	1	36.1
-.00	19.35	22.78	-16.73	35.39	41.67	2	43.5

TABLE A-1 (CONT)

Iflight= 13 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	2	1	1900	35.40	56.26	66.47	0	0.00	16.08	1.37	17.45
79	2	1	1900	11.56	19.24	22.44	1	0.00	9.19	-1.52	7.67
79	2	1	1900	8.33	18.15	19.97	2	0.00	14.43	-1.54	12.88
79	2	5	1800	8.36	27.98	29.20	0	0.00	-28.54	3.63	-24.91
79	2	5	1800	6.31	9.73	11.59	1	.00	2.95	-1.86	1.09
79	2	5	1800	4.89	17.13	17.81	2	.00	-13.49	-1.90	-15.39
79	2	6	1901	11.03	24.56	26.93	0	-.00	-22.18	4.09	-18.10
79	2	6	1901	5.82	14.27	15.41	1	-.00	15.51	-4.24	11.27
79	2	6	1901	3.61	7.52	8.34	2	-.00	9.48	-4.26	5.22
79	2	7	1930	23.66	43.56	49.57	0	0.00	-32.16	7.27	-24.89
79	2	7	1930	13.51	21.00	24.97	1	0.00	6.30	-1.63	4.68
79	2	7	1930	12.36	27.08	29.77	2	0.00	-17.83	-1.73	-19.56
79	2	8	1900	28.75	52.99	60.28	0	0.00	-37.98	7.63	-30.35
79	2	8	1900	16.74	25.63	30.62	1	0.00	-5.55	1.87	-3.67
79	2	8	1900	13.71	46.98	48.94	2	0.00	-43.84	1.72	-42.12
79	2	13	1900	23.63	36.42	43.42	0	0.00	-3.65	-3.52	-7.17
79	2	13	1900	5.81	40.86	41.27	1	0.00	-52.91	13.03	-39.88
79	2	13	1900	2.60	83.14	83.18	2	0.00	-95.91	12.88	-83.04
79	2	14	1915	12.32	38.91	40.81	0	0.00	-45.35	11.26	-34.09
79	2	14	1915	12.06	19.17	22.65	1	0.00	7.33	-1.75	5.58
79	2	14	1915	12.50	36.23	38.33	2	0.00	-28.97	-1.90	-30.87
79	2	15	2115	10.04	16.38	19.21	0	0.00	-16.53	10.35	-6.18
79	2	15	2115	11.58	21.59	24.50	1	0.00	17.63	-4.71	12.93
79	2	15	2115	12.91	19.33	23.25	2	0.00	3.15	-4.81	-1.66
79	2	16	2000	14.90	27.01	30.84	0	-.00	-22.53	7.45	-15.[illegible]
79	2	16	2000	3.25	4.91	5.88	1	.00	2.37	-1.81	.57
79	2	16	2000	6.17	23.54	24.34	2	.00	-19.73	-1.90	-21.63
79	2	20	1945	18.33	30.06	35.20	0	0.00	5.90	6.45	12.35
79	2	20	1945	8.37	13.27	15.69	1	0.00	-5.17	1.12	-4.04
79	2	20	1945	11.31	28.35	30.52	2	0.00	-23.60	1.00	-22.60
79	2	22	1845	40.62	61.26	73.50	0	.00	-13.99	7.63	-6.36
79	2	22	1845	9.28	25.07	26.73	1	0.00	26.68	-5.85	20.83
79	2	22	1845	9.28	22.78	24.60	2	0.00	23.81	-5.90	17.90
79	2	27	1850	46.01	70.60	84.27	0	00	-25.14	13.16	-11.97
79	2	27	1850	18.96	29.39	34.97	1	0.00	-7.57	2.13	-5.44
79	2	27	1850	15.96	57.47	59.65	2	0.00	-53.96	1.91	-52.05
79	2	28	1846	49.73	75.47	90.38	0	.00	-8.74	14.71	5.97
79	2	28	1846	16.87	26.30	31.24	1	0.00	6.37	-1.34	5.03
79	2	28	1846	13.62	33.70	36.35	2	0.00	-24.88	-1.54	-26.42

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
.00	28.48	33.53	-11.03	45.67	53.77	0	54.7
-.00	11.80	13.90	[illegible].28	22.70	26.7[illegible]	1	25.5
.00	10.68	12.5[illegible]	-21.19	31.20	36.7[illegible]	2	39.2

TABLE A-1 (CONT)

Iflight= 12 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	3	1	1937	58.23	88.03	105.54	0	-.00	-19.44	18.16	-1.28
79	3	1	1937	29.09	46.75	55.06	1	-.00	18.16	-2.86	15.30
79	3	1	1937	27.89	46.41	54.15	2	.00	-16.68	-2.35	-19.02
79	3	2	1900	40.87	62.59	74.75	0	.00	-26.12	16.80	-9.32
79	3	2	1900	29.14	48.50	56.59	1	-.00	23.25	-3.43	19.82
79	3	2	1900	28.49	44.67	52.99	2	-.00	-8.18	-2.90	-11.08
79	3	5	2200	4.72	21.60	22.11	0	-.00	-27.60	7.27	-20.33
79	3	5	2200	10.74	16.33	19.54	1	.00	-.26	.30	.04
79	3	5	2200	12.79	34.14	36.46	2	.00	-28.98	.92	-28.06
79	3	7	1945	4.86	30.51	30.89	0	-.00	-43.28	13.71	-29.57
79	3	7	1945	13.87	21.11	25.25	1	.00	-1.38	-.34	-1.72
79	3	7	1945	15.96	53.67	55.99	2	.00	-48.09	.19	-47.90
79	3	8	2130	13.85	59.90	61.48	0	.00	-68.20	12.08	-56.12
79	3	8	2130	9.53	19.23	21.46	1	.00	15.32	-2.58	12.74
79	3	8	2130	8.92	31.38	32.63	2	-.00	-26.36	-1.99	-28.35
79	3	12	1930	16.90	67.33	69.41	0	0.00	-77.01	14.71	-62.30
79	3	12	1930	8.12	12.50	14.90	1	0.00	3.54	-1.34	2.20
79	3	12	1930	6.49	55.39	55.76	2	-.00	-53.70	-.80	-54.51
79	3	14	1915	22.19	33.90	40.51	0	0.00	-12.65	7.46	-5.19
79	3	14	1915	8.37	20.95	22.56	1	0.00	-20.62	3.98	-16.64
79	3	14	1915	9.01	56.31	57.03	2	0.00	-59.17	4.54	-54.63
79	3	16	2150	18.55	28.28	33.82	0	0.00	-10.07	6.46	-3.61
79	3	16	2150	3.68	7.14	8.03	1	0.00	-7.40	3.05	-4.36
79	3	16	2150	1.45	32.72	32.76	2	0.00	-36.28	3.64	-32.64
79	3	19	1900	3.20	21.25	21.49	0	0.00	-23.54	2.82	-20.72
79	3	19	1900	.20	7.77	7.77	1	0.00	-12.51	4.75	-7.76
79	3	19	1900	1.91	38.93	38.98	2	0.00	-44.18	5.37	-38.82
79	3	26	2030	36.74	55.68	66.71	0	.00	7.71	-1.35	6.36
79	3	26	2030	10.34	33.38	34.95	1	0.00	-38.42	8.92	-29.49
79	3	26	2030	9.41	60.33	61.05	2	0.00	-68.16	9.54	-58.62
79	3	28	1925	31.35	47.84	57.19	0	0.00	-2.81	-3.99	-6.80
79	3	28	1925	10.28	18.93	21.54	1	0.00	-14.46	3.84	-10.63
79	3	28	1925	8.28	23.37	24.80	2	0.00	-24.22	4.55	-19.66
79	3	30	1900	17.87	42.01	45.66	0	0.00	-30.21	-1.90	-32.10
79	3	30	1900	8.13	12.54	14.94	1	.00	-2.70	1.75	-.95
79	3	30	1900	6.51	18.48	19.59	2	0.00	-17.96	2.46	-15.50

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
.00	27.66	32.56	-20.08	46.70	54.98	0	57.6
-.00	14.57	17.16	-1.79	25.82	30.40	1	29.6
-.00	14.26	16.80	-34.07	26.92	31.70	2	45.6

TABLE A-1 (CONT)

Iflight= 13 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	4	2	1900	34.35	69.88	77.86	0	0.00	-50.93	3.82	-47.11
79	4	2	1900	4.73	9.08	10.24	1	0.00	7.53	-2.04	5.49
79	4	2	1900	1.43	4.22	4.46	2	0.00	6.59	-2.93	3.66
79	4	4	1915	42.74	64.37	77.27	0	-.00	2.28	-4.17	-1.88
79	4	4	1915	8.54	15.65	17.83	1	0.00	-10.84	2.08	-8.76
79	4	4	1915	14.79	24.32	28.47	2	.00	7.95	1.24	9.20
79	4	6	1940	22.94	38.99	45.24	0	0.00	29.86	-11.52	18.34
79	4	6	1940	23.63	46.30	51.99	1	0.00	-40.74	11.37	-29.37
79	4	6	1940	24.62	40.66	47.53	2	0.00	-26.44	10.50	-15.94
79	4	9	1900	34.52	52.97	63.23	0	0.00	-8.34	-1.54	-9.87
79	4	9	1900	7.72	14.83	16.71	1	0.00	-14.64	5.25	-9.39
79	4	9	1900	6.99	13.17	14.91	2	0.00	-12.12	4.33	-7.79
79	4	11	1945	39.36	59.44	71.29	0	-.00	4.84	-6.07	-1.23
79	4	11	1945	12.59	21.14	24.61	1	0.00	-12.89	3.99	-8.91
79	4	11	1945	14.87	24.35	28.53	2	0.00	6.08	3.15	9.23
79	4	12	1931	37.35	56.73	67.92	0	.00	9.53	-3.80	5.72
79	4	12	1931	20.70	35.95	41.49	1	0.00	-21.08	3.65	-17.43
79	4	12	1931	18.89	28.93	34.55	2	0.00	-7.02	2.79	-4.23
79	4	16	1900	29.61	55.05	62.51	0	0.00	-33.23	1.19	-32.04
79	4	16	1900	18.07	27.67	33.04	1	0.00	5.37	-1.34	4.03
79	4	16	1900	20.96	33.70	39.68	2	0.00	13.68	-2.21	11.48
79	4	18	1920	22.46	45.75	50.96	0	0.00	-24.84	-6.07	-30.91
79	4	18	1920	10.36	16.46	19.45	1	0.00	-10.15	3.99	-6.16
79	4	18	1920	5.53	8.36	10.02	2	0.00	-.63	3.15	2.52
79	4	20	1930	8.33	59.80	60.38	0	0.00	-59.11	.64	-58.46
79	4	20	1930	3.80	6.47	7.50	1	0.00	-2.21	-.80	-3.01
79	4	20	1930	2.64	8.46	8.87	2	0.00	-5.69	-1.66	-7.35
79	4	23	2200	3.40	50.75	50.87	0	.00	-47.42	-3.07	-50.49
79	4	23	2200	3.92	14.59	15.10	1	-.00	-16.26	2.92	-13.34
79	4	23	2200	2.91	19.05	19.27	2	.00	-20.57	2.06	-18.51
79	4	25	2140	2.91	87.04	87.08	0	0.00	-87.48	.55	-86.93
79	4	25	2140	5.16	7.94	9.47	1	-.00	.59	1.22	1.82
79	4	25	2140	2.83	15.99	16.24	2	0.00	-15.75	.34	-15.41
79	4	30	1800	12.95	27.31	30.22	0	.00	-12.87	-6.16	-19.03
79	4	30	1800	9.72	28.43	30.05	1	-.00	-32.21	7.94	-24.27
79	4	30	1800	10.89	31.44	33.27	2	-.00	-33.74	7.05	-26.69

CROSS	C SIG	2D PE	RANGE	R SIG	20 PE	J	RMS
-.00	28.00	32.96	-26.16	51.50	60.63	0	63.9
-.00	12.60	14.84	-9.11	21.71	25.56	1	26.6
.00	13.19	15.53	-4.99	23.31	27.44	2	27.1

TABLE A-1 (CONT)

Iflight= 8 Iazimuth= 2

J=0 IS DEFAULT STD, J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	5	2	1947	17.25	70.99	73.06	0	0.00	-62.66	-3.44	-66.10
79	5	2	1947	6.95	16.12	17.56	1	0.00	-17.51	5.22	-12.29
79	5	2	1947	7.50	21.99	23.23	2	0.00	-19.57	.69	-18.88
79	5	7	1800	8.37	57.03	57.64	0	.00	-50.76	-4.90	-55.66
79	5	7	1800	3.86	5.98	7.11	1	.00	.37	-1.05	-.68
79	5	7	1800	4.06	19.35	19.77	2	.00	23.79	-5.48	18.31
79	5	11	1900	22.40	94.68	97.30	0	0.00	-92.32	3.82	-88.50
79	5	11	1900	1.65	3.06	3.48	1	0.00	1.94	-.11	1.83
79	5	11	1900	1.35	12.46	12.54	2	0.00	-7.64	-4.67	-12.30
79	5	18	1800	20.83	71.93	74.89	0	0.00	-61.82	-2.90	-64.71
79	5	18	1800	2.99	9.09	9.57	1	0.00	-10.60	2.74	-7.86
79	5	18	1800	2.77	8.93	9.35	2	0.00	-6.08	-1.76	-7.85
79	5	21	1800	23.13	78.17	81.52	0	0.00	-68.29	-1.71	-70.00
79	5	21	1800	8.98	13.58	16.28	1	0.00	-.88	-.37	-1.25
79	5	21	1800	8.58	13.45	15.95	2	0.00	8.57	-4.85	3.72
79	5	23	1445	23.30	72.61	76.26	0	0.00	-59.64	-3.99	-63.63
79	5	23	1445	3.64	5.91	6.94	1	0.00	-2.19	-.03	-2.21
79	5	23	1445	4.67	11.51	12.42	2	0.00	13.57	-4.48	9.09
79	5	25	1800	19.03	64.19	66.95	0	.00	-53.63	-3.80	-57.43
79	5	25	1800	8.58	14.06	16.47	1	-.00	-9.38	3.65	-5.72
79	5	25	1800	9.40	14.28	17.10	2	-.00	-1.54	-.86	-2.39
79	5	29	2148	17.28	49.52	52.50	0	0.00	-40.72	-1.54	-42.25
79	5	29	2148	4.14	8.95	9.86	1	.00	8.90	-2.48	6.42
79	5	29	2148	3.19	28.59	28.77	2	0.00	35.12	-6.94	28.19

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
.00	19.65	23.14	-63.54	32.07	37.76	0	73.7
.00	5.74	6.76	-2.72	10.24	12.06	1	12.0
.00	5.92	6.97	2.24	17.41	20.50	2	19.4

Iflight= 9 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	6	1	2145	24.90	75.32	79.33	0	0.00	-62.45	-2.90	-65.34
79	6	1	2145	14.64	23.57	27.74	1	0.00	-13.19	4.67	-8.51
79	6	1	2145	12.29	26.03	28.78	2	0.00	15.38	3.05	18.44
79	6	4	1800	15.78	52.93	55.23	0	0.00	-43.57	-3.71	-47.28
79	6	4	1800	3.82	20.93	21.28	1	0.00	-27.53	7.42	-20.11
79	6	4	1800	1.09	4.84	4.96	2	0.00	-1.22	5.77	4.56
79	6	6	1815	22.60	46.75	51.92	0	0.00	-29.16	-2.90	-32.06
79	6	6	1815	4.53	15.34	15.99	1	0.00	-18.43	4.67	-13.76
79	6	6	1815	8.29	26.29	27.57	2	0.00	20.08	3.05	23.13
79	6	8	1804	32.34	94.42	99.80	0	0.00	-77.53	-3.44	-80.97
79	6	8	1804	2.44	3.63	4.38	1	0.00	1.20	-.57	.63
79	6	8	1804	1.62	38.89	38.92	2	0.00	40.92	-2.12	38.81
79	6	13	1815	25.22	86.03	89.65	0	0.00	-71.27	-5.89	-77.16
79	6	13	1815	5.20	19.03	19.73	1	0.00	-23.00	5.73	-17.27
79	6	13	1815	3.74	9.06	9.80	2	.00	2.84	4.14	6.97
79	6	25	1750	36.76	90.96	98.11	0	0.00	-72.20	.02	-72.18
79	6	25	1750	6.46	16.91	18.10	1	0.00	-17.51	3.69	-13.82
79	6	25	1750	9.14	14.43	17.08	2	0.00	2.17	2.05	4.22
79	6	27	2005	35.61	90.80	97.53	0	0.00	-62.96	-10.24	-73.20
79	6	27	2005	13.58	21.20	25.18	1	0.00	-9.55	4.30	-5.25
79	6	27	2005	10.68	41.28	42.64	2	0.00	35.23	2.78	38.00
79	6	29	1730	39.43	113.85	120.49	0	0.00	-95.70	-1.35	-97.05
79	6	29	1730	10.99	16.78	20.06	1	0.00	-1.94	1.20	-.75
79	6	29	1730	7.97	25.42	26.64	2	0.00	22.71	-.40	22.31

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
0.00	30.31	35.69	-68.16	49.50	58.28	0	89.2
0.00	8.94	10.52	-9.95	15.30	18.02	1	20.2
.00	7.96	9.37	19.55	17.77	20.92	2	27.5

TABLE A-2. METEOROLOGIDAL DATA

Rocketsondc Data at Missing Layers   Iflight= 16

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	1	4	1900	2400	263	30	-56	52.78
79	1	4	1900	2500	259	30	-52	43.99
79	1	4	1900	2600	252	29	-49	37.17
79	1	5	1900	2400	265	24	-56	51.57
79	1	5	1900	2500	257	25	-54	43.80
79	1	5	1900	2600	253	28	-52	37.34
79	1	8	2030	2400	268	19	-57	51.51
79	1	8	2030	2500	262	23	-55	43.66
79	1	8	2030	2600	257	29	-51	36.83
79	1	11	1945	2400	265	16	-58	51.77
79	1	11	1945	2500	265	21	-56	43.88
79	1	11	1945	2600	267	26	-53	37.09
79	1	12	1900	2400	257	21	-56	51.47
79	1	12	1900	2500	252	24	-53	43.53
79	1	12	1900	2600	256	29	-50	36.76
79	1	15	2230	2400	250	18	-54	51.29
79	1	15	2230	2500	248	18	-53	43.64
79	1	15	2230	2600	246	24	-52	37.46
79	1	16	2145	2400	248	20	-56	[illegible]
79	1	16	2145	2500	251	22	-55	43.52
79	1	16	2145	2600	248	24	-52	36.77
79	1	17	2010	2400	281	5	-54	51.12
79	1	17	2010	2500	271	9	-55	44.03
79	1	17	2010	2600	273	10	-51	37.11
79	1	18	1720	2400	41	6	-54	51.74
79	1	18	1720	2500	51	9	-52	44.01
79	1	18	1720	2600	54	11	-50	37.43
79	1	19	1930	2400	65	12	-53	51.19
79	1	19	1930	2500	72	16	-51	43.53
79	1	19	1930	2600	74	20	-50	37.24
79	1	23	1835	2400	51	17	-54	51.05
79	1	23	1835	2500	56	12	-54	43.69
79	1	23	1835	2600	63	12	-54	37.44
79	1	24	1915	2400	57	16	-54	50.51
79	1	24	1915	2500	60	18	-54	43.21
79	1	24	1915	2600	55	19	-52	36.74
79	1	25	1800	2400	45	15	-59	51.91
79	1	25	1800	2500	42	15	-58	44.22
79	1	25	1800	2600	33	15	-59	37.86
79	1	26	1800	2400	39	11	-60	51.64
79	1	26	1800	2500	34	12	-61	44.12
79	1	26	1800	2600	28	11	-61	37.71
79	1	29	1700	2400	92	16	-55	51.21
79	1	29	1700	2500	97	23	-54	43.32
79	1	29	1700	2600	98	29	-51	36.77
79	1	30	1900	2400	103	16	-52	50.31
79	1	30	1900	2500	103	20	-50	42.92
79	1	30	1900	2600	102	22	-49	36.68

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	289	4	-58.92	59.65
2	285	4	-57.50	50.76
3	284	4	-56.19	43.20
4	283	4	-54.88	36.59

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
[illegible]	[illegible]

WIND(m/s)				TEMP(oC)		DENS(g m)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
1.03	5.81	-4.03	16.33	-55.56	2.19	51.36	[illegible]
.16	6.65	-3.75	18.57	-54.19	2.66	43.70	[illegible]
-.54	7.78	-4.55	20.97	-52.25	2.34	37.14	[illegible]

TABLE A-2 (CONT)

Rocketsonde Data At Missing Layers Iflight= 13

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	2	1	1900	2400	101	9	-54	50.67
79	2	1	1900	2500	97	12	-53	43.15
79	2	1	1900	2600	89	15	-51	36.76
79	2	5	1800	2400	311	1	-55	51.83
79	2	5	1800	2500	271	3	-54	44.11
79	2	5	1800	2600	262	5	-53	37.54
79	2	6	1901	2400	25	3	-54	51.43
79	2	6	1901	2500	36	4	-55	44.09
79	2	6	1901	2600	43	4	-53	37.48
79	2	7	1930	2400	83	6	-58	52.14
79	2	7	1930	2500	88	8	-56	44.18
79	2	7	1930	2600	84	10	-53	37.31
79	2	8	1900	2400	73	7	-58	52.26
79	2	8	1900	2500	73	10	-56	44.27
79	2	8	1900	2600	76	12	-54	37.56
79	2	13	1900	2400	85	6	-55	51.90
79	2	13	1900	2500	81	8	-49	43.30
79	2	13	1900	2600	89	10	-47	36.78
79	2	14	1915	2400	104	2	-59	52.29
79	2	14	1915	2500	88	4	-58	44.46
79	2	14	1915	2600	91	7	-57	37.83
79	2	15	2115	2400	139	2	-58	51.46
79	2	15	2115	2500	155	4	-58	43.92
79	2	15	2115	2600	198	5	-56	37.24
79	2	16	2000	2400	230	5	-57	51.64
79	2	16	2000	2500	239	5	-56	43.97
79	2	16	2000	2600	252	5	-55	37.52
79	2	20	1945	2400	257	8	-57	51.05
79	2	20	1945	2500	270	6	-55	43.23
79	2	20	1945	2600	273	4	-55	37.15
79	2	22	1845	2400	252	13	-58	51.65
79	2	22	1845	2500	261	15	-56	43.76
79	2	22	1845	2600	276	12	-54	37.10
79	2	27	1850	2400	253	12	-60	51.83
79	2	27	1850	2500	251	15	-59	43.98
79	2	27	1850	2600	253	20	-58	37.51
79	2	28	1846	2400	248	13	-61	51.50
79	2	28	1846	2500	247	16	-60	43.66
79	2	28	1846	2600	243	22	-58	36.99

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	281	5	-58.82	59.65
2	279	6	-57.50	50.76
3	277	6	-55.79	43.20
4	276	6	-53.88	36.59

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-1.11	2.38	-1.25	7.56	-57.23	2.20	51.66	.46
-1.02	2.85	-.89	9.46	-55.77	2.83	43.85	.41
-1.09	3.69	-.74	11.43	-54.15	3.00	37.29	.32

TABLE A-2 (CONT)

Rocketsonde Data At Missing Layers Iflight= 12

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	3	1	1937	2400	240	14	-63	51.81
79	3	1	1937	2500	236	20	-62	43.94
79	3	1	1937	2600	239	25	-59	37.00
79	3	2	1900	2400	251	9	-63	52.03
79	3	2	1900	2500	239	14	-61	44.08
79	3	2	1900	2600	233	19	-56	37.07
79	3	5	2200	2400	22	1	-58	52.01
79	3	5	2200	2500	224	2	-56	44.09
79	3	5	2200	2600	216	4	-53	37.24
79	3	7	1945	2400	75	1	-61	52.44
79	3	7	1945	2500	221	2	-59	44.39
79	3	7	1945	2600	222	4	-58	37.58
79	3	8	2130	2400	233	3	-60	53.10
79	3	8	2130	2500	230	5	-59	45.00
79	3	8	2130	2600	242	6	-55	37.78
79	3	12	1930	2400	255	4	-61	53.25
79	3	12	1930	2500	262	6	-60	45.15
79	3	12	1930	2600	263	7	-58	38.17
79	3	14	1915	2400	276	7	-59	51.92
79	3	14	1915	2500	254	7	-56	43.65
79	3	14	1915	2600	253	9	-52	36.84
79	3	16	2150	2400	272	5	-59	51.77
79	3	16	2150	2500	265	6	-55	43.64
79	3	16	2150	2600	262	8	-52	36.80
79	3	19	1900	2400	82	2	-56	51.95
79	3	19	1900	2500	93	1	-53	43.88
79	3	19	1900	2600	0	0	-52	37.41
79	3	26	2030	2400	256	12	-54	51.09
79	3	26	2030	2500	250	12	-51	43.22
79	3	26	2030	2600	244	13	-49	36.91
79	3	28	1925	2400	246	9	-51	51.04
79	3	28	1925	2500	251	10	-50	43.56
79	3	28	1925	2600	251	13	-49	37.26
79	3	30	1900	2400	258	4	-53	51.99
79	3	30	1900	2500	282	6	-51	44.07
79	3	30	1900	2600	296	9	-49	37.60

CLIMATOLOGY (A S T D) INPUT					STD ATMOSPHERE	
LA	AZ	SP	TEMP	DENS	TEMP	DENS
1	264	5	-56.82	59.65	-55.08	59.76
2	268	5	-55.50	50.76	-53.09	50.97
3	267	6	-54.19	43.20	-52.09	43.51
4	266	6	-52.82	36.59	-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-1.48	2.33	-4.94	4.71	-58.17	3.90	52.03	.66
-2.83	3.43	-6.61	5.05	-56.08	4.17	44.05	.57
-3.66	4.65	-8.54	5.98	-53.67	3.82	37.70	.42

TABLE A-2 (CONT)

Rocketsonde Data At Missing Layers Iflight= 13

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	4	2	1900	2400	257	11	-56	52 53
79	4	2	1900	2500	262	12	-54	44.56
79	4	2	1900	2600	269	11	-52	37.85
79	4	4	1915	2400	254	14	-52	51.16
79	4	4	1915	2500	248	14	-50	43.45
79	4	4	1915	2600	242	15	-47	36.80
79	4	6	1940	2400	259	10	-49	50.43
79	4	6	1940	2500	240	7	-45	42.70
79	4	6	1940	2600	216	7	-45	36.76
79	4	9	1900	2400	284	11	-53	51.34
79	4	9	1900	2500	287	11	-51	43 61
79	4	9	1900	2600	279	13	-50	37.30
79	4	11	1945	2400	244	11	-51	51.09
79	4	11	1945	2500	250	13	-49	43.36
79	4	11	1945	2600	255	16	-46	36.85
79	4	12	1931	2400	241	9	-52	50.83
79	4	12	1931	2500	252	13	-50	43.28
79	4	12	1931	2600	259	16	-48	36.93
79	4	16	1900	2400	250	6	-55	52.14
79	4	16	1900	2500	264	11	-53	44 20
79	4	16	1900	2600	273	13	-49	37.39
79	4	18	1920	2400	289	9	-51	51.78
79	4	18	1920	2500	287	7	-49	44.01
79	4	18	1920	2600	245	9	-46	37.46
79	4	20	1930	2400	339	4	-54	52 69
79	4	20	1930	2500	309	2	-53	44 [illegible]
79	4	20	1930	2600	274	4	-49	37.81
79	4	23	2200	2400	265	1	-54	5[illegible] 62
79	4	23	2200	2500	208	1	-5[illegible]	44 41
79	4	23	2200	2600	206	2	-47	37.71
79	4	25	2140	2400	146	1	-55	53.50
79	4	25	2140	2500	156	1	-52	45.33
79	4	25	2140	2600	119	1	-[illegible]0	38.50
79	4	30	1800	2400	275	4	-52	51.67
79	4	30	1800	2500	251	4	-48	43.63
79	4	30	1800	2600	232	6	-47	37.28

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	244	2	-55.72	60.60
2	245	1	-53.75	51.31
3	255	1	-52.19	43.54
4	260	2	-50.82	37.28

STD ATMOSPHERE

TEMP	DENS
-55.08	59.[illegible]6
-53.09	50.[illegible]7
-52.09	43.51
-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	1	SIG	D	SIG
-.89	2.89	-6.87	4.50	-52.83	2.04	51.81	.90
-1.38	2.63	-7.42	5.04	-50.33	2.50	43.95	.75
-2.20	2.75	-8.44	5.79	-48.00	2.04	37.38	.52

Table A-2 (cont)

Rocketsonde Data At Missing Layers   Iflight= 8

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	5	2	1947	2400	254	6	-52	52.60
79	5	2	1947	2500	251	6	-50	44.85
79	5	2	1947	2600	240	5	-49	38.30
79	5	7	1800	2400	175	4	-50	52.13
79	5	7	1800	2500	195	3	-50	44.68
79	5	7	1800	2600	195	1	-48	38.11
79	5	11	1900	2400	64	7	-56	53.55
79	5	11	1900	2500	68	8	-54	45.44
79	5	11	1900	2600	67	7	-52	38.66
79	5	18	1800	2400	96	6	-53	52.78
79	5	18	1800	2500	89	7	-50	44.76
79	5	18	1800	2600	87	8	-49	38.17
79	5	21	1800	2400	97	7	-54	53.04
79	5	21	1800	2500	102	8	-51	44.96
79	5	21	1800	2600	100	8	-48	38.00
79	5	23	1445	2400	83	8	-51	52.30
79	5	23	1445	2500	82	8	-50	44.84
79	5	23	1445	2600	74	7	-49	38.43
79	5	25	1800	2400	63	5	-52	52.50
79	5	25	1800	2500	58	7	-50	44.59
79	5	25	1800	2600	76	7	-48	38.11
79	5	29	2148	2400	87	6	-53	52.08
79	5	29	2148	2500	96	6	-51	44.34
79	5	29	2148	2600	92	5	-50	37.95

CLIMATOLOGY (A S T D) INPUT					STD ATMOSPHERE	
LA	AZ	SP	TEMP	DENS	TEMP	DENS
1	93	3	-54.72	61.61	-55.08	59.76
2	95	3	-52.76	52.32	-53.09	50.97
3	96	3	-50.79	44.31	-52.09	43.51
4	98	3	-40.82	37.59	-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-.06	2.25	4.02	4.57	-52.63	1.85	52.62	.50
.10	2.37	4.45	4.97	-50.75	1.39	44.80	.32
.22	1.81	4.53	4.45	-49.13	1.36	38.21	.24

Table A-2 (cont)

Rocketsonde Data At Missing Layers   Iflight= 8

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	6	1	2145	2400	62	7	-53	52.79
79	6	1	2145	2500	64	9	-50	44.76
79	6	1	2145	2600	84	9	-49	38.23
79	6	4	1800	2400	104	5	-54	52.72
79	6	4	1800	2500	100	5	-49	44.21
79	6	4	1800	2600	102	6	-48	37.64
79	6	6	1815	2400	122	8	-53	52.06
79	6	6	1815	2500	115	7	-50	44.00
79	6	6	1815	2600	105	8	-49	37.57
79	6	8	1804	2400	102	11	-52	53.13
79	6	8	1804	2500	104	11	-50	45.10
79	6	8	1804	2600	97	10	-49	38.53
79	6	13	1815	2400	109	8	-52	53.13
79	6	13	1815	2500	95	8	-49	44.97
79	6	13	1815	2600	85	10	-45	38.16
79	6	25	1750	2400	97	12	-56	53.43
79	6	25	1750	2500	89	12	-52	44.97
79	6	25	1750	2600	87	13	-47	37.83
79	6	27	2005	2400	90	10	-49	52.66
79	6	27	2005	2500	100	12	-47	44.94
79	6	27	2005	2600	92	14	-43	38.01
79	6	29	1730	2400	89	11	-54	53.73
79	6	29	1730	2500	91	13	-51	45.48
79	6	29	1730	2600	95	16	-49	38.68

CLIMATOLOGY (A S T D) INPUT					STD ATMOSPHERE	
LA	AZ	SP	TEMP	DENS	TEMP	DENS
1	93	8	-53.72	62.61	-55.08	59.76
2	94	9	-51.76	53.32	-53.09	50.97
3	94	9	-49.79	45.32	-52.09	43.51
4	93	10	-47.88	35.36	-51.10	37.17

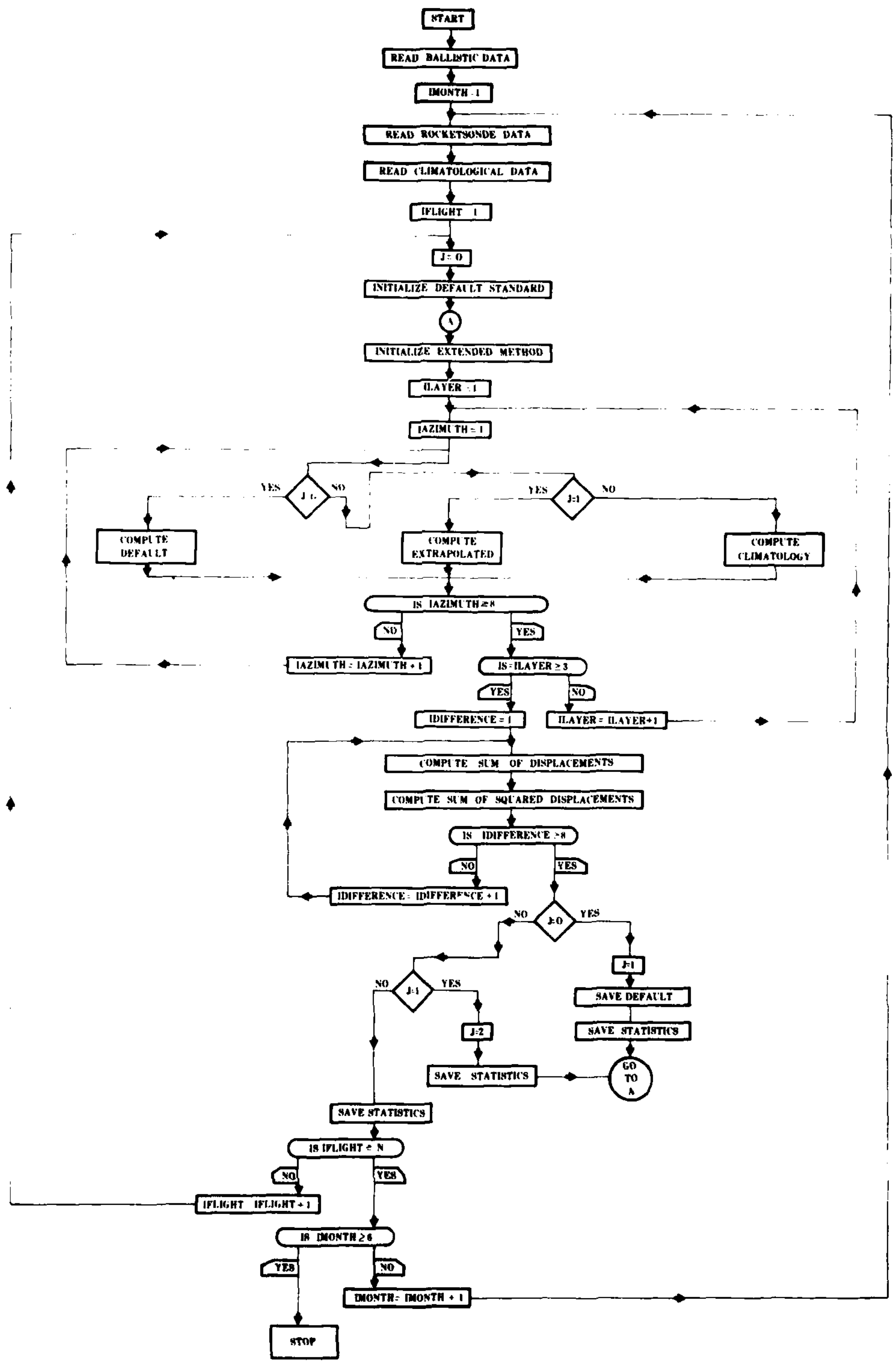
WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-1.04	2.26	8.63	2.61	-52.88	2.03	52.95	.52
-.67	2.19	9.35	2.93	-49.75	1.49	44.80	.48
-.49	1.18	10.67	3.38	-47.38	2.26	38.08	.40

APPENDIX B

EXTENDED MESSAGE COMPARISON

The logic used to formulate the computation and comparison of the expected meteorological errors associated with methods of extending meteorological information at heights above the artillery computer meteorological message is presented by a flowchart. By examination of the report sections on ballistic simulation and technique comparison, one can define the actual computations presented in this report.

EXTENDED MESSAGE COMPARISON FLOWCHART



DISTRIBUTION LIST

Commander
US Army Aviation Center
ATTN: ATZQ-D-MA
Fort Rucker, AL 36362

Chief, Atmospheric Sciences Div
Code ES-81
NASA
Marshall Space Flight Center, AL 35812

Commander
US Army Missile Command
ATTN: DRDMI-RRA/Dr.O. M. Essenwanger
Redstone Arsenal, AL 35809

Commander
US Army Missile Command
ATTN: DRSMI-OG (B. W. Fowler)
Redstone Arsenal, AL 35809

Commander
US Army Missile R&D Command
ATTN: DRDMI-TEM (R. Haraway)
Redstone Arsenal, AL 35809

Redstone Scientific Information Center
ATTN: DRSMI-RPRD (Documents)
US Army Missile Command
Redstone Arsenal, AL 35809

Commander
HQ, Fort Huachuca
ATTN: Tech Ref Div
Fort Huachuca, AZ 85613

Commander
US Army Intelligence
Center & School
ATTN: ATSI-CD-MD
Fort Huachuca, AZ 85613

Commander
US Army Yuma Proving Ground
ATTN: Technical Library
Bldg 2105
Yuma, AZ 85364

Dr. Frank D. Eaton
Geophysical Institute
University of Alaska
Fairbanks, AK 99701

Naval Weapons Center
Code 3918
ATTN: Dr. A. Shlanta
China Lake, CA 93555

Commanding Officer
Naval Envir Prediction Rsch Facility
ATTN; Library
Monterey, CA 93940

Sylvania Elec Sys Western Div
ATTN: Technical Reports Lib
PO Box 205
Mountain View, CA 94040

Geophysics Officer
PMTC Code 3250
Pacific Missile Test Center
Point Mugu, CA 93042

Commander
Naval Ocean Systems Center
(Code 4473)
ATTN: Technical Library
San Diego, CA 92152

Meteorologist in Charge
Kwajalein Missile Range
PO Box 67
APO San Francisco, CA 96555

Director
NOAA/ERL/APCL R31
RB3-Room 567
Boulder, CO 80302

Dr.B. A. Silverman D-1200
Office of Atmos Resources Management
Water and Power Resources Service
PO Box 25007Denver Federal Center, Bldg. 67
Denver, CO 80225

Hugh W. Albers (Executive Secretary)
CAO Subcommittee on Atmos Rsch
National Science Foundation Room 510
Washington, DC 2055

Dr. Eugene W. Bierly
Director, Division of Atmos Sciences
National Scinece Foundation
1800 G Street, N.W.
Washington, DC 20550

Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20375

Defense Communications Agency
Technical Library Center
Code 222
Washington, DC 20305

Director
Naval Research Laboratory
Code 5530
Washington, DC 20375

Dr. J. M. MacCallum
Naval Research Laboratory
Code 1409
Washington, DC 20375

HQDA (DAEN-RDM/Dr. de Percin)
Washington, DC 20314

The Library of Congress
ATTN: Exchange & Gift Div
Washington, DC 20540
2

Mil Asst for Atmos Sci Ofc of
the Undersecretary of Defense
for Rsch & Engr/E&LS - RM 3D129
The Pentagon
Washington, DC 20301

AFATL/DLODL
Technical Library
Eglin AFB, FL 32542

Naval Training Equipment Center
ATTN: Technical Information Center
Orlando, FL 32813

Technical Library
Chemical Systems Laboratory
Aberdeen Proving Ground, MD 21010

US Army Materiel Systems
Analysis Activity
ATTN: DRXSY-MP
APG, MD 21005

Commander
ERADCOM
ATTN: DRDEL-PA/ILS/-ED
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-ST-T (Dr. B. Zarwyn)
2800 Powder Mill Road
Adelphi, MD 20783
02

Commander
Harry Diamond Laboratories
ATTN: DELHD-CO
2800 Powder Mill Road
Adelphi, MD 20783

Chief
Intel Mat Dev & Spt Ofc
ATTN: DELEW-WL-I
Bldg 4554
Fort George G. Mead, MD 20755

Acquisitions Section, IRDB-D823
Library & Info Svc Div, NOAA
6009 Executive Blvd.
Rockville, MD 20752

Naval Surface Weapons Center
White Oak Library
Silver Spring, MD 20910

Air Force Geophysics Laboratory
ATTN: LCC (A. S. Carten, Jr.)
Hanscom AFB, MA 01731

Air Force Geophysics Laboratory
ATTN: LYD
Hanscom AFB, MA 01731

Meteorology Division
AFGL/LY
Hanscom AFB, MA 01731

The Environmental Research
Institute of MI
ATTN: IRIA Library
PO Box 8618
Ann Arbor, MI 48107

Mr. William A. Main
USDA Forest Service
1407 S. Harrison Road
East Lansing, MI 48823

Dr. A. D. Belmont
Research Division
PO Box 1249
Control Data Corp
Minneapolis, MN 55440

Commander
Naval Oceanography Command
Bay St. Louis, MS 39529

Commanding Officer
US Army Armament R&D Command
ATTN; DRDAR-TSS Bldg 59
Dover, NJ 07801

Commander
ERADCOM Scientific Advisor
ATTN: DRDEL-SA
Fort Monmouth, NJ 07703

Commander
ERADCOM Tech Support Activity
ATTN: DELSD-L
Fort Monmouth, NJ 07703

Commander
HQ, US Army Avionics R&D Actv
ATTN: DAVAA-O
Fort Monmouth, NJ 07703

Commander
USA Elect Warfare Lab
ATTN: DELEW-DA (File Cy)
Fort Monmouth, NJ 07703

Commander
US Army Electronics R&D Command
ATTN: DELCS-S
Fort Monmouth, NJ 07703

Commander
US Army Satellite Comm Agency
ATTN: DRCPM-SC-3
Fort Monmouth, NJ 07703

Commander/Director
US Army Combat Survl & Target
Acquisition Laboratory
ATTN: DELCS-D
Fort Monmouth, NJ 07703

Director
Night Vision & Electro-Optics Laboratory
ATTN: DELNV-L (Dr. R. Buser)
Fort Belvoir, VA 22060

Project Manager, FIREFINDER
ATTN: DRCPM-FF
Fort Monmouth, NJ 07703

PM, Firefinder/REMBASS
ATTN: DRCPM-FFR-TM
Fort Monmouth, NJ 07703

6585 TG/WE
Holloman AFB, NM 88330

AFWL/Technical Library (SUL)
Kirtland AFB, NM 87117

AFWL/WE
Kirtland, AFB, NM 87117

TRASANA
ATTN: ATAA-SL (D. Anguiano)
WSMR, NM 88002

Commander
US Army White Sands Missile Range
ATTN: STEWS-PT-AL
White Sands Missile Range, NM 88002

Rome Air Development Center
ATTN: Documents Library
TSLD (Bette Smith)
Griffiss AFB, NY 13441

Environmental Protection Agency
Meteorology Laboratory, MD 80
Rsch Triangle Park, NC 27711

US Army Research Office
ATTN: DRXRO-PP
PO Box 12211
Rsch Triangle Park, NC 27709

Commandant
US Army Field Artillery School
ATTN: ATSF-CD-MS (Mr. Farmer)
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: ATSF-CF-R
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: Morris Swett Library
Fort Sill, OK 73503

Commander
US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-M
(Mr. Paul Carlson)
Dugway, UT 84022

Commander
US Army Dugway Proving Ground
ATTN: MT-DA-L
Dugway, UT 84022

US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-T
(Dr. W. A. Peterson)
Dugway, UT 84022

Inge Dirmhirn, Professor
Utah State University, UMC 48
Logan, UT 84322

Defense Technical Information Center
ATTN: DTIC-DDA-2
Cameron Station, Bldg. 5
Alexandria, VA 22314
12

Commanding Officer
US Army Foreign Sci & Tech Cen
ATTN: DRXST-IS1
220 7th Street, NE
Charlottesville, VA 22901

Naval Surface Weapons Center
Code G65
Dahlgren, VA 22448

Commander
US Army Night Vision
& Electro-Optics Lab
ATTN: DELNV-D
Fort Belvoir, VA 22060

Commander
USATRADOC
ATTN: ATCD-FA
Fort Monroe, VA 23651

Commander
USATRADOC
ATTN: ATCD-IR
Fort Monroe, VA 23651

Dept of the Air Force
5WW/DN
Langley AFB, VA 23665

US Army Nuclear & Cml Agency
ATTN: MONA-WE
Springfield, VA 22150

Director
US Army Signals Warfare Lab
ATTN: DELSW-OS (Dr. Burkhardt)
Vint Hill Farms Station
Warrenton, VA 22186

Commander
US Army Cold Regions Test Cen
ATTN: STECR-OP-PM
APO Seattle, WA 98733

ATMOSPHERIC SCIENCES RESEARCH PAPERS

1. Lindberg, J.D., "An Improvement to a Method for Measuring the Absorption Coefficient of Atmospheric Dust and other Strongly Absorbing Powders," ECOM-5565, July 1975.
2. Avara, Elton, P., "Mesoscale Wind Shears Derived from Thermal Winds," ECOM-5566, July 1975.
3. Gomez, Richard B., and Joseph H. Pierluissi, "Incomplete Gamma Function Approximation for King's Strong-Line Transmittance Model," ECOM-5567, July 1975.
4. Blanco, A.J., and B.F. Engebos, "Ballistic Wind Weighting Functions for Tank Projectiles," ECOM-5568, August 1975.
5. Taylor, Fredrick J., Jack Smith, and Thomas H. Pries, "Crosswind Measurements through Pattern Recognition Techniques," ECOM-5569, July 1975.
6. Walters, D.L., "Crosswind Weighting Functions for Direct-Fire Projectiles," ECOM-5570, August 1975.
7. Duncan, Louis D., "An Improved Algorithm for the Iterated Minimal Information Solution for Remote Sounding of Temperature," ECOM-5571, August 1975.
8. Robbiani, Raymond L., "Tactical Field Demonstration of Mobile Weather Radar Set AN/TPS-41 at Fort Rucker, Alabama," ECOM-5572, August 1975.
9. Miers, B., G. Blackman, D. Langer, and N. Lorimier, "Analysis of SMS/GOES Film Data," ECOM-5573, September 1975.
10. Manquero, Carlos, Louis Duncan, and Rufus Bruce, "An Indication from Satellite Measurements of Atmospheric CO2 Variability," ECOM-5574, September 1975.
11. Petracca, Carmine, and James D. Lindberg, "Installation and Operation of an Atmospheric Particulate Collector," ECOM-5575, September 1975.
12. Avara, Elton P., and George Alexander, "Empirical Investigation of Three Iterative Methods for Inverting the Radiative Transfer Equation," ECOM-5576, October 1975.
13. Alexander, George D., "A Digital Data Acquisition Interface for the SMS Direct Readout Ground Station — Concept and Preliminary Design," ECOM-5577, October 1975.
14. Cantor, Israel, "Enhancement of Point Source Thermal Radiation Under Clouds in a Nonattenuating Medium," ECOM-5578, October 1975.
15. Norton, Colburn, and Glenn Hoidale, "The Diurnal Variation of Mixing Height by Month over White Sands Missile Range, N.M," ECOM-5579, November 1975.
16. Avara, Elton P., "On the Spectrum Analysis of Binary Data," ECOM-5580, November 1975.
17. Taylor, Fredrick J., Thomas H. Pries, and Chao-Huan Huang, "Optimal Wind Velocity Estimation," ECOM-5581, December 1975.
18. Avara, Elton P., "Some Effects of Autocorrelated and Cross-Correlated Noise on the Analysis of Variance," ECOM-5582, December 1975.
19. Gillespie, Patti S., R.L. Armstrong, and Kenneth O. White, "The Spectral Characteristics and Atmospheric CO2 Absorption of the Ho^{+3}:YLF Laser at 2.05μm," ECOM-5583, December 1975.
20. Novlan, David J. "An Empirical Method of Forecasting Thunderstorms for the White Sands Missile Range," ECOM-5584, February 1976.
21. Avara, Elton P., "Randomization Effects in Hypothesis Testing with Autocorrelated Noise," ECOM-5585, February 1976.
22. Watkins, Wendell R., "Improvements in Long Path Absorption Cell Measurement," ECOM-5586, March 1976.
23. Thomas, Joe, George D. Alexander, and Marvin Dubbin, "SATTEL — An Army Dedicated Meteorological Telemetry System," ECOM-5587, March 1976.
24. Kennedy, Bruce W., and Delbert Bynum, "Army User Test Program for the RDT&E-XM-75 Meteorological Rocket," ECOM-5588, April 1976.

25. Barnett, Kenneth M., "A Description of the Artillery Meteorological Comparisons at White Sands Missle Range, October 1974 - December 1974 ('PASS' - *Prototype Artillery [Meteorological] Subsystem*)," ECOM-5589, April 1976.

26. Miller, Walter B., "Preliminary Analysis of Fall-of-Shot From Project 'PASS'," ECOM-5590, April 1976.

27. Avara, Elton P., "Error Analysis of Minimum Information and Smith's Direct Methods for Inverting the Radiative Transfer Equation," ECOM-5591, April 1976.

28. Yee, Young P., James D. Horn, and George Alexander, "Synoptic Thermal Wind Calculations from Radiosonde Observations Over the Southwestern United States," ECOM-5592, May 1976.

29. Duncan, Louis D., and Mary Ann Seagraves, "Applications of Empirical Corrections to NOAA-4 VTPR Observations," ECOM-5593, May 1976.

30. Miers, Bruce T., and Steve Weaver, "Applications of Meterological Satellite Data to Weather Sensitive Army Operations,"ECOM-5594, May 1976.

31. Sharenow, Moses, "Redesign and Improvement of Balloon ML-566," ECOM-5595, June, 1976.

32. Hansen, Frank V., "The Depth of the Surface Boundary Layer," ECOM-5596, June 1976.

33. Pinnick, R.G., and E.B. Stenmark, "Response Calculations for a Commercial Light-Scattering Aerosol Counter," ECOM-5597, July 1976.

34. Mason, J., and G.B. Hoidale, "Visibility as an Estimator of Infrared Transmittance," ECOM-5598, July 1976.

35. Bruce, Rufus E., Louis D. Duncan, and Joseph H. Pierluissi, "Experimental Study of the Relationship Between Radiosonde Temperatures and Radiometric-Area Temperatures," ECOM-5599, August 1976.

36. Duncan, Louis D., "Stratospheric Wind Shear Computed from Satellite Thermal Sounder Measurements," ECOM-5800, September 1976.

37. Taylor, F., P. Mohan, P. Joseph and T. Pries, "An All Digital Automated Wind Measurement System," ECOM-5801, September 1976.

38. Bruce, Charles, "Development of Spectrophones for CW and Pulsed Radiation Sources," ECOM-5802, September 1976.

39. Duncan, Louis D., and Mary Ann Seagraves,"Another Method for Estimating Clear Column Radiances," ECOM-5803, October 1976.

40. Blanco, Abel J., and Larry E. Taylor, "Artillery Meteorological Analysis of Project Pass," ECOM-5804, October 1976.

41. Miller, Walter, and Bernard Engebos," A Mathematical Structure for Refinement of Sound Ranging Estimates," ECOM-5805, November, 1976.

42. Gillespie, James B., and James D. Lindberg, "A Method to Obtain Diffuse Reflectance Measurements from 1.0 to 3.0 μm Using a Cary 171 *Spectrophotometer*," ECOM-5806, November 1976.

43. Rubio, Roberto, and Robert O. Olsen,"A Study of the Effects of Temperature Variations on Radio Wave Absorption,"ECOM-5807, November 1976.

44. Ballard, Harold N., "Temperature Measurements in the Stratosphere from Balloon-Borne Instrument Platforms, 1968-1975," ECOM-5808, December 1976.

45. Monahan, H.H., "An Approach to the Short-Range Prediction of Early Morning Radiation Fog," ECOM-5809, January 1977.

46. Engebos, Bernard Francis, "Introduction to Multiple State Multiple Action Decision Theory and Its Relation to Mixing Structures," ECOM-5810, January 1977.

47. Low, Richard D.H.,"Effects of Cloud Particles on Remote Sensing from Space in the 10-Micrometer Infrared Region," ECOM-5811, January 1977.

48 Bonner, Robert S., and R. Newton, "Application of the AN/GVS-5 Laser Rangefinder to Cloud Base Height Measurements," ECOM-5812, February 1977.

49. Rubio, Roberto, "Lidar Detection of Subvisible Reentry Vehicle Erosive Atmospheric Material," ECOM-5813, March 1977.

50. Low, Richard D.H., and J.D. Horn, "Mesoscale Determination of Cloud-Top Height: Problems and Solutions," ECOM-5814, March 1977.

51. Duncan, Louis D., and Mary Ann Seagraves, "Evaluation of the NOAA-4 VTPR Thermal Winds for Nuclear Fallout Predictions," ECOM-5815, March 1977.
52. Randhawa, Jagir S., M. Izquierdo, Carlos McDonald and Zvi Salpeter, "Stratospheric Ozone Density as Measured by a Chemiluminescent Sensor During the Stratcom VI-A Flight," ECOM-5816, April 1977.
53. Rubio, Roberto, and Mike Izquierdo, "Measurements of Net Atmospheric Irradiance in the 0.7- to 2.8-Micrometer Infrared Region," ECOM-5817, May 1977.
54. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson Consultant for Chemical Kinetics, "Calculation of Selected Atmospheric Composition Parameters for the Mid-Latitude, September Stratosphere," ECOM-5818, May 1977.
55. Mitchell, J.D., R.S. Sagar, and R.O. Olsen, "Positive Ions in the Middle Atmosphere During Sunrise Conditions," ECOM-5819, May 1977.
56. White, Kenneth O., Wendell R. Watkins, Stuart A. Schleusener, and Ronald L. Johnson, "Solid-State Laser Wavelength Identification Using a Reference Absorber," ECOM-5820, June 1977.
57. Watkins, Wendell R., and Richard G. Dixon, "Automation of Long-Path Absorption Cell Measurements," ECOM-5821, June 1977.
58. Taylor, S.E., J.M. Davis, and J.B. Mason, "Analysis of Observed Soil Skin Moisture Effects on Reflectance," ECOM-5822, June 1977.
59. Duncan, Louis D. and Mary Ann Seagraves, "Fallout Predictions Computed from Satellite Derived Winds," ECOM-5823, June 1977.
60. Snider, D.E., D.G. Murcray, F.H. Murcray, and W.J. Williams, "Investigation of High-Altitude Enhanced Infrared Backround Emissions" (U), SECRET, ECOM-5824, June 1977.
61. Dubbin, Marvin H. and Dennis Hall, "Synchronous Meteorological Satellite Direct Readout Ground System Digital Video Electronics," ECOM-5825, June 1977.
62. Miller, W., and B. Engebos, "A Preliminary Analysis of Two Sound Ranging Algorithms," ECOM-5826, July 1977.
63. Kennedy, Bruce W., and James K. Luers, "Ballistic Sphere Techniques for Measuring Atomspheric Parameters," ECOM-5827, July 1977
64. Duncan, Louis D., "Zenith Angle Variation of Satellite Thermal Sounder Measurements," ECOM-5828, August 1977.
65. Hansen, Frank V., "The Critical Richardson Number," ECOM-5829, September 1977.
66. Ballard, Harold N., and Frank P. Hudson (Compilers), "Stratospheric Composition Balloon-Borne Experiment," ECOM-5830, October 1977.
67. Barr, William C., and Arnold C. Peterson, "Wind Measuring Accuracy Test of Meteorological Systems," ECOM-5831, November 1977.
68. Ethridge, G.A. and F.V. Hansen, "Atmospheric Diffusion: Similarity Theory and Empirical Derivations for Use in Boundary Layer Diffusion Problems," ECOM-5832, November 1977.
69. Low, Richard D.H., "The Internal Cloud Radiation Field and a Technique for Determining Cloud Blackness," ECOM-5833, December 1977.
70. Watkins, Wendell R., Kenneth O. White, Charles W. Bruce, Donald L. Walters, and James D. Lindberg, "Measurements Required for Prediction of High Energy Laser Transmission," ECOM-5834, December 1977.
71. Rubio, Robert, "Investigation of Abrupt Decreases in Atmospherically Backscattered Laser Energy," ECOM-5835, December 1977.
72. Monahan, H.H. and R.M. Cionco, "An Interpretative Review of Existing Capabilities for Measuring and Forecasting Selected Weather Variables (Emphasizing Remote Means)," ASL-TR-0001, January 1978.
73. Heaps, Melvin G., "The 1979 Solar Eclipse and Validation of D-Region Models," ASL-TR-0002, March 1978.

74. Jennings, S.G., and J.B. Gillespie, "M.I.E. Theory Sensitivity Studies - The Effects of Aerosol Complex Refractive Index and Size Distribution Variations on Extinction and Absorption Coefficients Part II: Analysis of the Computational Results," ASL-TR-0003, March 1978.
75. White, Kenneth O. et al, "Water Vapor Continuum Absorption in the 3.5μm to 4.0μm Region," ASL-TR-0004, March 1978.
76. Olsen, Robert O., and Bruce W. Kennedy, "ABRES Pretest Atmospheric Measurements," ASL-TR-0005, April 1978.
77. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson, "Calculation of Atmospheric Composition in the High Latitude September Stratosphere," ASL-TR-0006, May 1978.
78. Watkins, Wendell R. et al, "Water Vapor Absorption Coefficients at HF Laser Wavelengths," ASL-TR-0007, May 1978.
79. Hansen, Frank V., "The Growth and Prediction of Nocturnal Inversions," ASL-TR-0008, May 1978.
80. Samuel, Christine, Charles Bruce, and Ralph Brewer, "Spectrophone Analysis of Gas Samples Obtained at Field Site," ASL-TR-0009, June 1978.
81. Pinnick, R.G. et al., "Vertical Structure in Atmospheric Fog and Haze and its Effects on IR Extinction," ASL-TR-0010, July 1978.
82. Low, Richard D.H., Louis D. Duncan, and Richard B. Gomez, "The Microphysical Basis of Fog Optical Characterization," ASL-TR-0011, August 1978.
83. Heaps, Melvin G., "The Effect of a Solar Proton Event on the Minor Neutral Constituents of the Summer Polar Mesosphere," ASL-TR-0012, August 1978.
84. Mason, James B., "Light Attenuation in Falling Snow," ASL-TR-0013, August 1978.
85. Blanco, Abel J., "Long-Range Artillery Sound Ranging: "PASS" Meteorological Application," ASL-TR-0014, September 1978.
86. Heaps, M.G., and F.E. Niles, "Modeling the Ion Chemistry of the D-Region: A case Study Based Upon the 1966 Total Solar Eclipse," ASL-TR-0015, September 1978.
87. Jennings, S.G., and R.G. Pinnick, "Effects of Particulate Complex Refractive Index and Particle Size Distribution Variations on Atmospheric Extinction and Absorption for Visible Through Middle-Infrared Wavelengths," ASL-TR-0016, September 1978.
88. Watkins, Wendell R., Kenneth O. White, Lanny R. Bower, and Brian Z. Sojka, " Pressure Dependence of the Water Vapor Continuum Absorption in the 3.5- to 4.0-Micrometer Region," ASL-TR-0017, September 1978.
89. Miller, W.B., and B.F. Engebos, "Behavior of Four Sound Ranging Techniques in an Idealized Physical Environment," ASL-TR-0018, September 1978.
90. Gomez, Richard G., "Effectiveness Studies of the CBU-88/B Bomb, Cluster, Smoke Weapon" (U), CONFIDENTIAL ASL-TR-0019, September 1978.
91. Miller, August, Richard C. Shirkey, and Mary Ann Seagraves, "Calculation of Thermal Emission from Aerosols Using the Doubling Technique," ASL-TR-0020, November, 1978.
92. Lindberg, James D. et al., "Measured Effects of Battlefield Dust and Smoke on Visible, Infrared, and Millimeter Wavelengths Propagation: A Preliminary Report on Dusty Infrared Test-I (DIRT-I)," ASL-TR-0021, January 1979.
93. Kennedy, Bruce W., Arthur Kinghorn, and B.R. Hixon, "Engineering Flight Tests of Range Meteorological Sounding System Radiosonde," ASL-TR-0022, February 1979.
94. Rubio, Roberto, and Don Hoock, "Microwave Effective Earth Radius Factor Variability at Wiesbaden and Balboa," ASL-TR-0023, February 1979.
95. Low, Richard D.H., "A Theoretical Investigation of Cloud/Fog Optical Properties and Their Spectral Correlations," ASL-TR-0024, February 1979.

96. Pinnick, R.G., and H.J. Auvermann, "Response Characteristics of Knollenberg Light-Scattering Aerosol Counters," ASL-TR-0025, February 1979.
97. Heaps, Melvin G., Robert O. Olsen, and Warren W. Berning, "Solar Eclipse 1979, Atmospheric Sciences Laboratory Program Overview," ASL-TR-0026 February 1979.
98. Blanco, Abel J., "Long-Range Artillery Sound Ranging: 'PASS' GR-8 Sound Ranging Data," ASL-TR-0027, March 1979.
99. Kennedy, Bruce W., and Jose M. Serna, "Meteorological Rocket Network System Reliability," ASL-TR-0028, March 1979.
100. Swingle, Donald M., "Effects of Arrival Time Errors in Weighted Range Equation Solutions for Linear Base Sound Ranging," ASL-TR-0029, April 1979.
101. Umstead, Robert K., Ricardo Pena, and Frank V. Hansen, "KWIK: An Algorithm for Calculating Munition Expenditures for Smoke Screening/Obscuration in Tactical Situations," ASL-TR-0030, April 1979.
102. D'Arcy, Edward M., "Accuracy Validation of the Modified Nike Hercules Radar," ASL-TR-0031, May 1979.
103. Rodriguez, Ruben, "Evaluation of the Passive Remote Crosswind Sensor," ASL-TR-0032, May 1979.
104. Barber, T.L., and R. Rodgriquez, "Transit Time Lidar Measurement of Near-Surface Winds in the Atmosphere," ASL-TR-0033, May 1979.
105. Low, Richard D.H., Louis D. Duncan, and Y.Y. Roger R. Hsiao, "Microphysical and Optical Properties of California Coastal Fogs at Fort Ord," ASL-TR-0034, June 1979.
106. Rodriguez, Ruben, and William J. Vechione, "Evaluation of the Saturation Resistant Crosswind Sensor," ASL-TR-0035, July 1979.
107. Ohmstede, William D., "The Dynamics of Material Layers," ASL-TR-0036, July 1979.
108. Pinnick, R.G., S.G. Jennings, Petr Chylek, and H.J. Auvermann "Relationships between IR Extinction, Absorption, and Liquid Water Content of Fogs," ASL-TR-0037, August 1979.
109. Rodriguez, Ruben, and William J. Vechione, "Performance Evaluation of the Optical Crosswind Profiler," ASL-TR-0038, August 1979.
110. Miers, Bruce T., "Precipitation Estimation Using Satellite Data" ASL-TR-0039, September 1979.
111. Dickson, David H., and Charles M. Sonnenschein, "Helicopter Remote Wind Sensor System Description," ASL-TR-0040, September 1979.
112. Heaps, Melvin, G., and Joseph M. Heimerl, "Validation of the Dairchem Code, I: Quiet Midlatitude Conditions," ASL-TR-0041, September 1979.
113. Bonner, Robert S., and William J. Lentz, "The Visioceilometer: A Portable Cloud Height and Visibility Indicator," ASL-TR-0042, October 1979.
114. Cohn, Stephen L., "The Role of Atmospheric Sulfates in Battlefield Obscurations," ASL-TR-0043, October 1979.
115. Fawbush, E.J. et al, "Characterization of Atmospheric Conditions at the High Energy Laser System Test Facility (HELSTF), White Sands Missile Range, New Mexico, Part I, 24 March to 8 April 1977," ASL-TR-0044, November 1979
116. Barber, Ted L., "Short-Time Mass Variation in Natural Atmospheric Dust," ASL-TR-0045, November 1979
117. Low, Richard D.H., "Fog Evolution in the Visible and Infrared Spectral Regions and its Meaning in Optical Modeling," ASL-TR-0046, December 1979
118. Duncan, Louis D. et al, "The Electro-Optical Systems Atmospheric Effects Library, Volume I: Technical Documentation, ASL-TR-0047, December 1979.
119. Shirkey, R. C. et al, "Interim E-O SAEL, Volume II, Users Manual," ASL-TR-0048, December 1979.
120. Kobayashi, H.K., "Atmospheric Effects on Millimeter Radio Waves," ASL-TR-0049, January 1980.
121. Seagraves, Mary Ann and Duncan, Louis D., "An Analysis of Transmittances Measured Through Battlefield Dust Clouds," ASL-TR-0050, February, 1980.

122. Dickson, David H., and Jon E. Ottesen, "Helicopter Remote Wind Sensor Flight Test," ASL-TR-0051, February 1980.

123. Pinnick, R. G., and S. G. Jennings, "Relationships Between Radiative Properties and Mass Content of Phosphoric Acid, HC, Petroleum Oil, and Sulfuric Acid Military Smokes," ASL-TR-0052, April 1980.

124. Hinds, B. D., and J. B. Gillespie, "Optical Characterization of Atmospheric Particulates on San Nicolas Island, California," ASL-TR-0053, April 1980.

125. Miers, Bruce T.,"Precipitation Estimation for Military Hydrology,"ASL-TR-0054, April 1980.

126. Stenmark, Ernest B., "Objective Quality Control of Artillery Computer Meteorological Messages," ASL-TR-0055, April 1980.

127. Duncan, Louis D., and Richard D. H. Low, "Bimodal Size Distribution Models for Fogs at Meppen, Germany," ASL-TR-0056, April 1980.

128. Olsen, Robert O., and Jagir S. Randhawa, "The Influence of Atmospheric Dynamics on Ozone and Temperature Structure," ASL-TR-0057, May 1980.

129. Kennedy, Bruce W., et al, "Dusty Infrared Test-II (DIRT-II) Program," ASL—TR-0058, May 1980.

130. Heaps, Melvin G., Roberts O. Olsen, Warren Berning, John Cross, and Arthur Gilcrease, "1979 Solar Eclipse,Part I - Atmospheric Sciences Laboratory Field Program Summary," ASL-TR-0059, May 1980.

131. Miller, Walter B.,"User's Guide for Passive Target Acquisition Program Two (PTAP-2)," ASL-TR-0060, June 1980.

132. Holt, E. H., editor, "Atmospheric Data Requirements for Battlefield Obscuration Applications," ASL-TR-0061, June 1980.

133. Shirkey, Richard C., August Miller, George H. Goedecke, and Yugal Behl, "Single Scattering Code AGAUSX: Theory, Applications, Comparisons, and Listing," ASL—TR-0062, July 1980.

134. Sojka, Brain Z., and Kenneth O. White, "Evaluation of Specialized Photoacoustic Absorption Chambers for Near-millimeter Wave (NMMW) Propagation Measurements," ASL-TR-0063, August 1980.

135. Bruce, Charles W., Young Paul Yee, and S. G. Jennings, "In Situ Measurement of the Ratio of Aerosol Absorption to Extinction Coefficient," ASL-TR-0064, August 1980.

136. Yee, Young Paul, Charles W. Bruce, and Ralph J. Brewer, "Gaseous/Particulate Absorption Studies at WSMR using Laser Sourced Spectrophones," ASL-TR-0065, June 1980.

137. Lindberg, James D., Radon B. Loveland, Melvin Heaps, James B. Gillespie, and Andrew F.Lewis,"Battlefield Dust and Atmospheric Characterization Measurements During West German Summertime Conditions in Support of Grafenwohr Tests," ASL-TR-0066, September 1980.

138. Vechione, W. J., "Evaluation of the Environmental Instruments, Incorporated Series 200 Dual Component Wind Set," ASL-TR-0067, September 1980.

139. Bruce, C. W., Y. P. Yee, B. D. Hinds, R. G. Pinnick, R. J. Brewer, and J. Minjares, "Initial Field Measurements of Atmospheric Absorption at 9μm to 11μm Wavelengths," ASL-TR-0068, October 1980.

140. Heaps, M. G., R. O. Olsen, K. D. Baker, D. A. Burt, L. C. Howlett, L. L. Jensen, E. F. Pound, and G. D. Allred, "1979 Solar Eclipse: Part II Initial Results for Ionization Sources, Electron Density, and Minor Neutral Constituents," ASL-TR-0069, October 1980.

141. Low, Richard D. H., "One-Dimensional Cloud Microphysical Models for Central Europe and their Optical Properties," ASL-TR-0070, October 1980.

142. Duncan, Louis D., James D. Lindberg, and Radon B. Loveland, "An Empirical Model of the Vertical Structure of German Fogs," ASL-TR-0071, November 1980.

143. Duncan, Louis D., 1981, "EOSAEL 80, Volume I, Technical Documentation," ASL-TR-0072, January 1981.
144. Shirkey, R. C., and S. G. O'Brien, "EOSAEL 80, Volume II, Users manual," ASL-TR-0073, January 1931.
145. Bruce, C. W., "Characterization of Aerosol Nonlinear Effects on a High-Power CO_2 Laser Beam," ASL-TR-0074 (Draft), February 1981.
146. Duncan, Louis D., and James D. Lindberg, "Air Mass Considerations in Fog Optical Modeling," ASL-TR-0075, February 1981.
147. Kunkel, Kenneth E., "Evaluation of a Tethered Kite Anemometer," ASL-TR-0076, February 1981.
148. Kunkel, K. E. et al, "Characterization of Atmospheric Conditions at the High Energy Laser System Test Facility (HELSTF) White Sands Missile Range, New Mexico, August 1977 to October 1978, Part II, Optical Turbulence, Wind, Water Vapor Pressure, Temperature," ASL-TR-0077, February 1981.
149. Miers, Bruce T., "Weather Scenarios for Central Germany," ASL-TR-0078, February 1981.
150. Cogan, James L., "Sensitivity Analysis of a Mesoscale Moisture Model," ASL-TR-0079, March 1981.
151. Brewer, R. J., C. W. Bruce, and J. L. Mater, "Optoacoustic Spectroscopy of C^2H^4 at the 9μM and 10μM $C^{12}O_2{}^{16}$ Laser Wavelengths," ASL-TR-0080, March 1981.
152. Swingle, Donald M., "Reducible Errors in the Artillery Sound Ranging Solution, Part I: The Curvature Correction" *(U), SECRET, ASL-TR-0081, April 1981.*
153. Miller, Walter B., "The Existence and Implications of a Fundamental System of Linear Equations in Sound Ranging" (U), SECRET, ASL-TR-0082, April 1981.
154. Bruce, Dorothy, Charles W. Bruce, and Young Paul Yee, "Experimentally Determined Relationship Between Extinction and Liquid Water Content," ASL-TR-0083, April 1981.
155. Seagraves, Mary Ann, "Visible and Infrared Obscuration Effects of Ice Fog," ASL-TR-0084, May 1981.
156. Watkins, Wendell R., and Kenneth O. White, "Wedge Absorption Remote Sensor," ASL-TR-0085, May 1981.
157. Watkins, Wendell R., Kenneth O. White, and Laura J. Crow, "Turbulence Effects on Open Air Multipaths," ASL-TR-0086, May 1981.
158. Blanco, Abel J., "Extending Application of the Artillery Computer Meteorological Message," ASL-TR-0087, May 1981.

☆U.S. GOVERNMENT PRINTING OFFICE: 1981-0-777-026/26

DATE
ILME